APRIL 1985

AVONDALE SHIPYARDS INC.

FITTING & WELDING CYLINDERS

ROGGENDORFF AND PARTNERS CO LTD.

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PROGRAM MANAGEMENT

This report is one of the many projects managed and cost-shared by Avondale Shipyards, Incorporated, under the auspices of the National Shipbuilding Research Program. The program is a cooperative effort between the Maritime Administration's office of Advanced Ship Development and the U.S. shipbuilding industry.

Executive administration and supervision were provided by Mr. E.L. James, Vice President, Production Planning, Avondale Shipyards, Incorporated; with Mr. Richard A. Price, MarAd Research & Development program manager, Avondale Shipyards, Incorporated.

Project definition was provided by the members of the Society of Naval Architects and Marine Engineers Panel SP-l Shipyard Facilities and Environmental Effects and Mr. R.W. Schaffran, Maritime Administration, Office of Advanced Ship Development. Technical advise was received from Eugene Aspuru, Manager of Plant Engineering and Maintenance Dept.

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INTRODUCTION

THE EVR CHANGING FACE OF THE MARINE AND OFF-SHORE CONSTRUCTION INDUSTRIES DEMANDS MANUFACTURING METHODS FOR RE-INFORCED TUBULARS AND PRESSURE VESSELS IN CONTINUALLY INCREASING DIAMETERS, WEIGHTS, ASSEMBLED LENGTHS AND TOLERANCES.

THE PRODUCTION REQUIRED CAN BE DIVIDED INTO 3 DIFFERENT CATEGORIES :-

MASS PRODUCTION OF IDENTICAL ITEMS

2: LARGE BATCH PRODUCTION WITHIN A RANGE OF DIAMETERS, WEIGHTS, ASSEMBLED LENGTHS ETC.

3: NON-REPEATING SINGLE ITEMS [TAILOR MADE]

CATEGORIES 1 & 2 CAN BE MECHANIZED
CATEGORY 3 SHOULD BE PRODUCED BY STANDARD SHIPBUILDING PRACTICE.

CATEGORY ONE CAN BE PERFORMED By THE USE OF HEAVY JIGS AND FIXTURES TO ASSEMBLE SHELLS WITHIN THE VERTICAL PLANE. AN INTEGRATED LOADING, UNLOADED AND TRANSFORT SYSTEM SHOULD BE PART OF THE PRODUCTION EQUIPMENT, THE PRODUCT IS OF GOOD QUALITY, BUT PRODUCTION IS SOMEWHAT SLOW AND THEREFORE SOME NUMBERS OF SUCH JIGS AND FIXTURES ARE REQUIREO. CARE MUST BE TAKEN NOT TO DEVELOP lNTERNAL STRESSES, WHICH COULD BE THE RESULT OF UNCONTROLLED HEAT INTRODUCTION DURING WELDING PROCEDURE. DUE TO VERTICAL MODE OF WORK, THE SYSTEM MUST BE RESTRICTED TO NOT MORE THAN TWO SHELL UNITS BEARING IN MIND THE EXTRA HEIGHT REQUIRED FOR LIFTING, TURNING AND RE-POSITIONING *OF* EACH UNIT.
IT SHOULD BE NOTED THAT THE INITIAL INVESTMENT FOR SUCH A SYSTEM, WHICH MUST BE SUBSTANTIALLY BUILT, IS EXCEPTIONALLY HIGH.

CATEGORY TWO CAN BE BEST PERFORMED THROUGH A PROGRESSIVE PRODUCTION LINE ASSISTED BY AN INTEGRATED TRANSPORT SYSTEM. AS AN EXAMPLE SUCH PRODUCTION LINE CAN BE BUILT TO COPE WITH TUBULARS/PRESSURE VESSELS OF BETWEEN 25 AND 45 FEET IN DIAMETER, A WEIGHT OF UP TO 10 TONS PER LINEAR FOOT AND TO AN UNSPECIFIED LENGTH WITHIN THE HORIZONTAL PLANE TO MEET INDIVIDUAL REQUIREMENTS. THE QUALITY OF PRODUCT WILL BE TO CLOSE TOLERANCES, WITHOUT LOCKED-IN INTERNAL STRESSES. IT SHOULD BE NOTED THAT THE INITIAL INVESTMENT FOR SUCH PRODUCTION LINE IS MUCH LOWER THAN THAT DESCRIBED IN CATEGORY ONE.

IN SHORT, CATEGORY ONE IS RIGID IN ITS CONCEPTION, WHEREAS CATEGORY TWO IS FLEXIBLE IN ITS APPLICATION.

THE OBJECT OF THIS FEASIBILITY STUDY IS THE MECHANISATION OF ALIGNING ASSEMBLING INTERNAL/EXTERNAL CIRCWELDING OF RE-INFORCED SHELLS AND THE FITTING OF SAME WITH AXIAL RE-INFORCING PROFILES ALL RELATIVE TO THE MANUFACTURE OF LARGE DIAMETERS TUBULARS.

THE BASIC REQUIREMENTS IN TUBULAR PRODUCTION IS CONCENTRICITY WITH FULL WELD PENETRATION WITHOUT LOCKED-IN STRESSES WITHIN THE STRUCTURE ITSELF.

AS THE OFFSHORE AND MARINE CONSTRUCTION INDUSTRIES CALL FOR A WIDE RANGE OF DIAMETERS, THE USE OF RIGID JIGS AND FIXTURES IS PROHIBITIVE FOR SEVERAL.. REASONS. FIRSTLY, THE LARGE NUMBER OF JIGS WHICH WOULD BE REQUIRED, THE AMOUNT OF SHOP FLOOR SPACE AND WORKING HEIGHT TO ACCOMMODATE THEM AND LASTLY, THE HIGH COST.

TAKING INTO CONSIDERATION ALL THESE POINTS, OBVIOUSLY THE ONLY ALTERNATIVE IS THE FLEXIBLE PRODUCTION METHOD DESCRIBED IN CATEGORY TWO.

FLEXIBLE SYSTEM CATEGORY TWO FOR THE ASSEMBLING OF SHELL UNIT TO SHELL UNIT TO FORM TUBULARS CALLED FLEXIBLE FOR 3 REASONS

1 : WILL COPE WITH SHELL ASSEMBLY/TUBULAR PRODUCTION BETWEEN DIAMETERS 25 AND 45 FEET WITHOUT MUCH PREPARATION OR EQUIPMENT SETTING TIME.

2 : WILL CARRY OUT ASSEMBLING WORK REGARDLESS OF CENTRE OF ROTATION BY SIMPLY ALIGNING AND MARRYING SHELL EDGE TO SHELL EDGE IN A CONSECUTIVE MANNER THROUGHOUT 360°OF THE CIRCUMFERENCE.

3 : WILL CARRY OUT RELATIVE EDGE POSITIONING TO SPECIFICATION AND ACCORDINGLY AUTOMATICALLY DISTRIBUTE ANY CIRCUMFERENTIAL DIFFERENCES DUE TO INCORRECT SHELL DIAMETER OR VARYING WALL THICKNESSES BETWEEN CONSECUTIVE SHELLS.

THE PRODUCTION SYSTEM WHICH IS THE SUBJECT OF OUR STUDY, WILL CONFORM TO THE ABOVE AND ASSEMBLE PRE-FABRICATED INDIVIDUAL SHELLS INTO TUBULARS WITH HIGH QUALITY WELDED J0INTS AND PROPERLY MATCHED Circumference THUS PRODUCING A PRESSURE VESSEL AS THE REQUIRED END RESULT, PROVIDED THAT INDIVIDUAL SHELLS ARE WITHIN MANUFACTURING LIMITS WITH PARALLEL EDGES FREE OF SERRATIONS.

THE CRITERIA IS NOT ONLY THE METHOD, BUT ALL THE EQUIPMENT WITH REGARD TO FUNCTION AND CONTROL BY AND WITHIN THE SYSTEM AND THEREFORE THE PRODUCTION SYSTEM SHOULD BE UNDERSTOOD AS A COMPLETE NON-DIVISABLE UNIT.

A PROVEN PRODUCTION SYSTEM FOR THE ASSEMBLING OF LARGE RE-INFORCED SHELLS WITH A WIDE VARIETY OF DIAMETERS IS DESCRIBED HEREINAFTER AND CONSISTS OF THE FOLLOWING ITEMs-

1 : A MOBILE WORK CENTRE SHIPYARD CROCODILE SELF-PROPELLED ON RAILS, OPERATING WITH ITS OWN PURPOSE BUILT TURNING ROLL SYSTEM.

2 : AN EXTERNAL COMBINED BACK GOUGING AND CIRC-WELDING MANIPULATOR.

3 : A RE-INFORCING PROFILE FEEDING AND WELDING MECHANISM OPERATING OVER TURNING ROLLS.

4 : A MOTORIZED LOADING TRANSPORT AND UNLOADING SYSTEM SERVING ALL THE ABOVE MENTIONED EQUIPMENT.

ADDENDUM ONE - DEALING WITH THE FITTING AND WELDING OF CYLINDERS IN THE LOWER RANGE BETWEEN 2 AND 14 FEET IN DIAMETER UP TO 4.5 TONS PER LINEAR FOOT AND LENGTH TO REQUIREMENT.

ADDENDUM TWO - IN ADDITION TO THE REQUIREMENT OF THIS FEASIBILITY STUDY, CONCERNING THE ASSEMBLING AND WELDING OF SHELLS AS MENTIONED ABOVEj WE ARE ALSO ENCLOSING *OUR* U.S. PATENT NO. 4,371,108 DESCRIBING A COMPLETE PRODUCTION SYSTEM FROM ROLLING OF PLATE TO FITTED TUBULARS.

THE PRODUCTION METHOD [CATEGORY TWO] DESCRIBED IN THE FEASIBILITY STUDY IS NOT A THEORETICAL CONCEPT BUT A PROVEN SYSTEM AS THE FOLLOWING EXAMPLES WILL TESTIFY :-

[A] THE CROCODILE / TYPE : 814 CYLINDRICAL VESSEL ASSEMBLING LINE

[B) TUBULAR PRODUCTION SYSTEM / TYPE : 813 SH [ADDENDUM TWO]

[c] SHIPYARD CROCODILE / TYPE :814 NS [LARGE DIAMETER RE-INFORCED SHELL ASSEMBLY LINE]

[A] WESTERN ROCK BIT LTD, CALGARY, CANADA.
CONTACT: MR LARRY CORLESS VICE PRESIDENT . MANUFACTURING.

ASSEMBLING SHELLS OF BETWEEN 5 AND 20 FEET IN DIAMETER WITH ALL THICKNESS OF 1/2" TO 21/2" AND A LOADING CAPACITY OF 6 TONS PER LINEAR FOOT.

PRODUCTION TIME SAVING OVER STANDARD MANUFACTURING METHODS - 80 - 85%

BABCOCK KREFELD, WEST GERMANY.
CONTACT : HERR BAUES PRODUCTION MANAGER

MAIN PRODUCT : ROTARY CEMENT KILNS, DIAMETER UP TO 20 FEET AND PLATE THICKNESS UP TO 4" AT DRIVING ZONES.

PRODUCTION TIME SAVING OVER STANDARD MANUFACTURING METHODS : 80%

[B] BROWN & ROOT - WIMPEY HIGHLAND FABRICATORS LTD. NICG ROSS-SHIRE SCOTLAND
CONTACTS : MR. JOHN PARKIN, QUALITY ASSURANCE MANAGER.
MR. JACK MITCHELL PIPE MILL MANAGER.

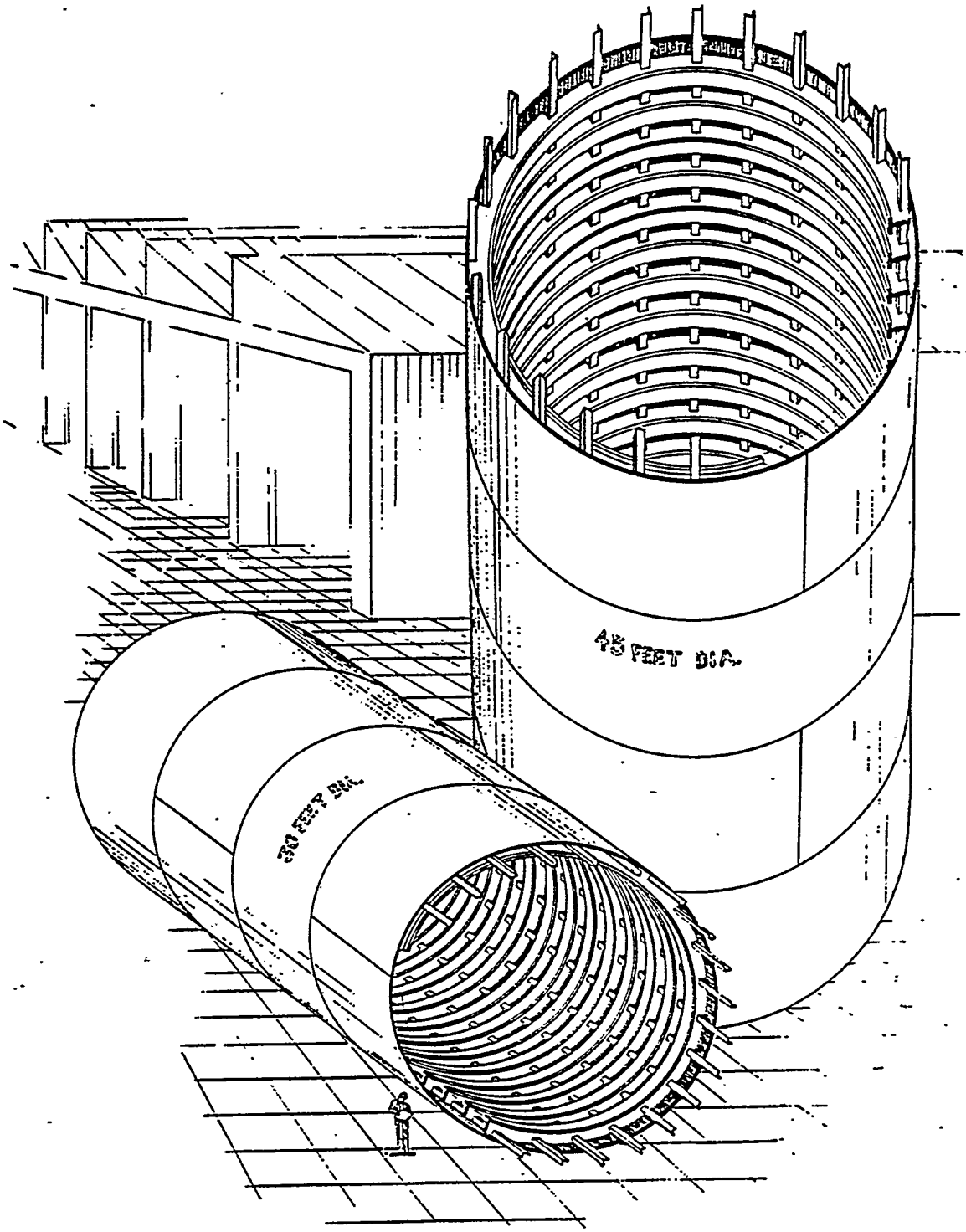
[1] PIPE RACK - 1978 [2] FIT-UP LINE FOR PIPE MILL - 1983 [3] PIPE RACK - 1984

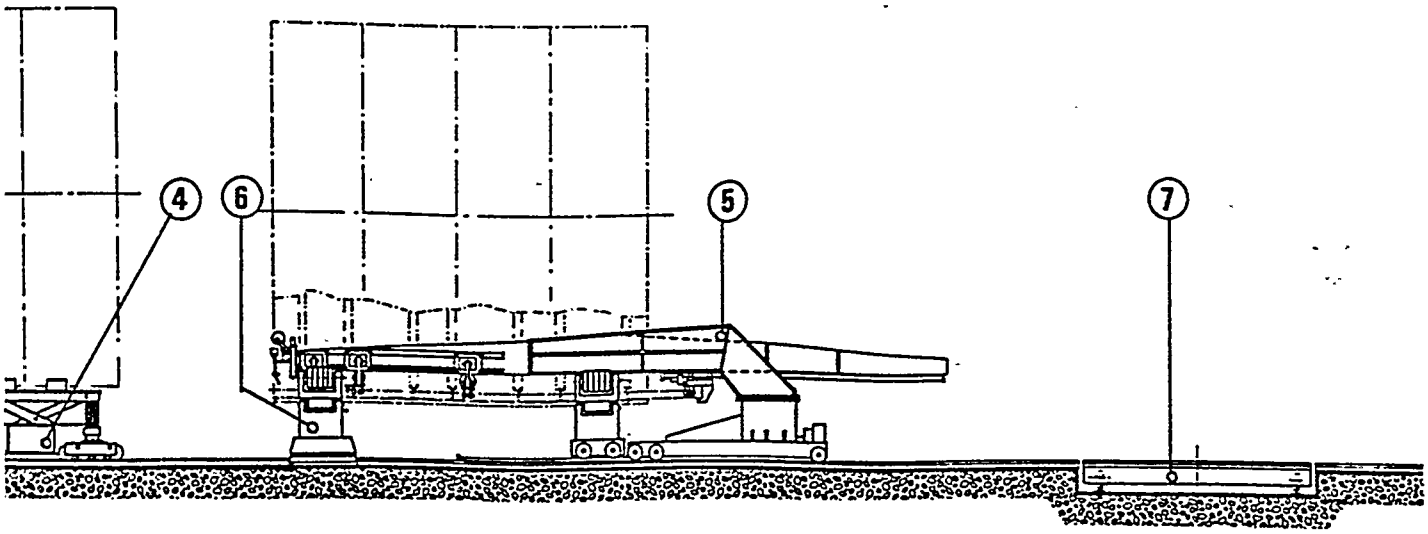
TUBULAR PRODUCTION - 2 - 10 FEET IN DIAMETER, 5 - 12 FEET IN INDIVIDUAL SHELL *LENGTH INTO 40* - 60 FEET IN FIT-UP LINE AND 160 - 180 FEET IN THE PIPE RACK. LOADING CAPACITY OF BOTH LINES 2 TONS PER LINEAR FOOT.

PRODUCTION TIME SAVING OVER STANDARD MANUFACTURING METHODS : 80 - 85% IN MANPOWER AND THROUGH-PUT.

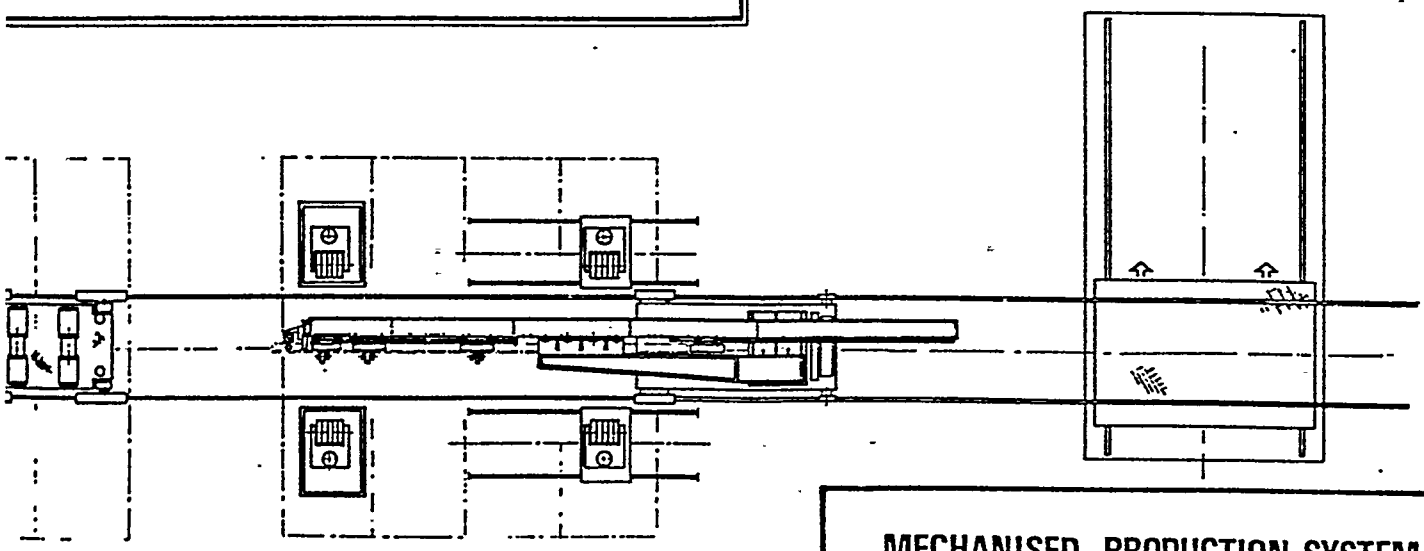
[c] BY THE VERY NATURE OF THE PRODUCTION - [SUBMARINE] - DATA IS NOT READILY AVAILABLE FOR SECURITY REASONS.

HOWEVER, OUR ASSOCIATES, MESSRS. DEUZER MASCHINENFABRIK GMBH., OF WEST GERMANY, MANUFACTURERS AND SUPPLIERS OF THE EQUIPMENT HAVE OBTAINED FROM ONE OF WEST GERMANY'S LEADING SUBMARINE MANUFACTURERS, A FIGURE OF 70% SAVING OVER STANDARD SHIPYARD MANUFACTURING PRACTICE.


45 FEET DIA.
30 FEET DIA.



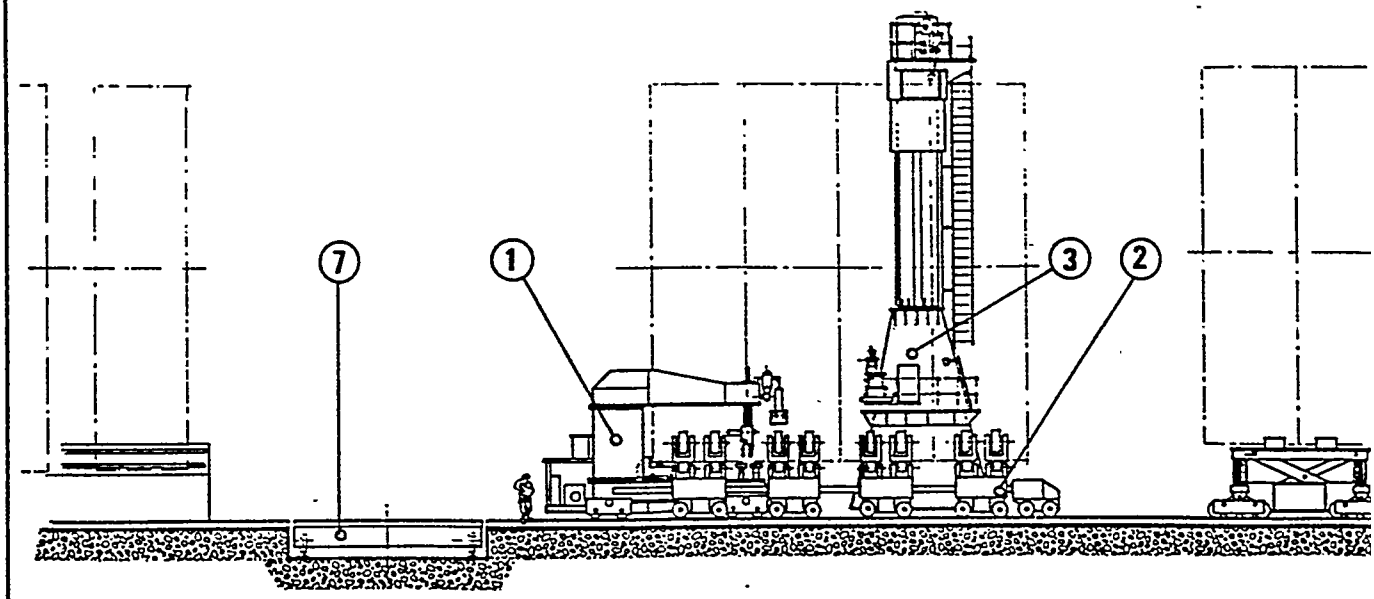
ıRD CROCODILE / MACHINE : TYPE 814 NS.
ıRD CROCODILE / TURNING ROLL SYSTEM
NAL WELDING BOOM / BACK GOUGE
- PROPELLED TRANSPORT CARRIAGE
REINFORCEMENT PROFILE FEEDER/WELDER
DARY TURNING ROLL SYSTEM
TRANSFER



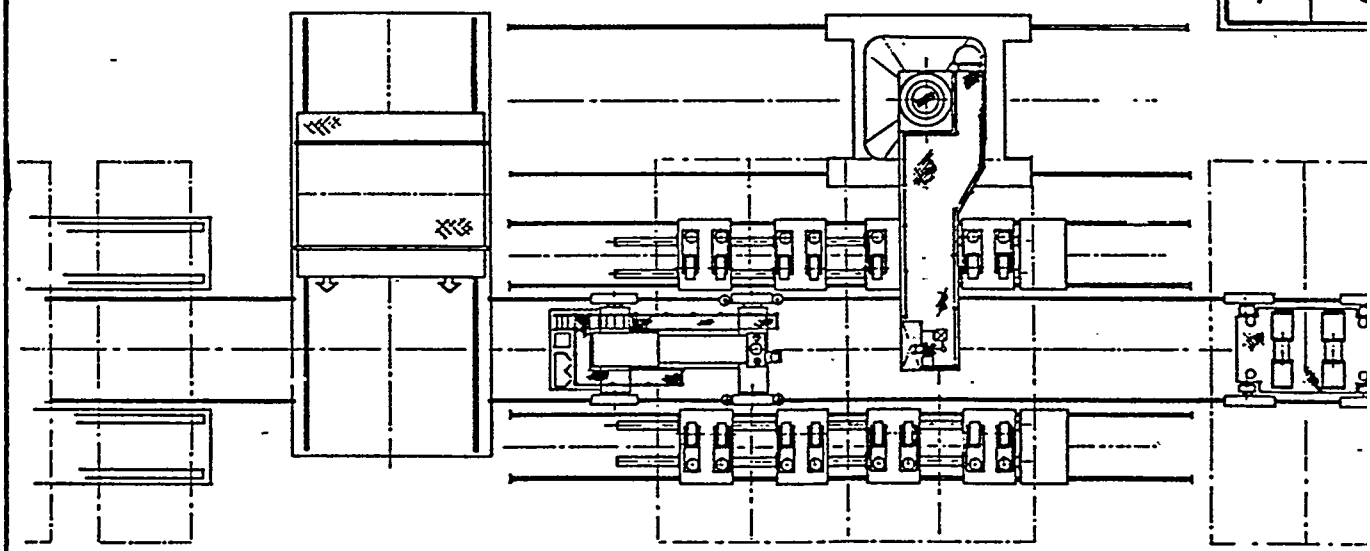
MECHANISED PRODUCTION SYSTEM

FOR FITTING AND WELDING

LARGE DIAMETER CYLINDERS



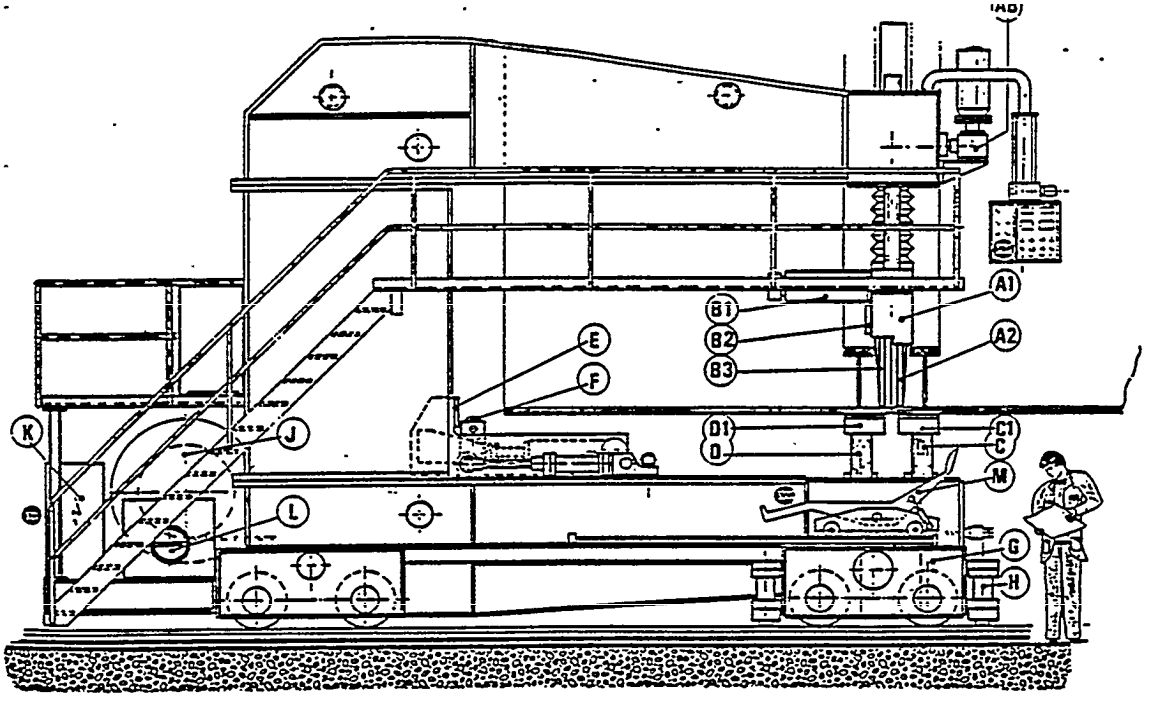
1	S
2	S
3	E
4	S
5	A
6	S
7	C



PART I

PRODUCTION EQUIPMENT

SHIPYARD CROCODILE/ MACHINE TYPE 814.NS.



TWO INTERNAL BACKSTOPS [DOWNSTROKING]

AB	STROKER-DRIVE FOR BACKSTOPS [A1 + B2]
A I	BACKSTOP/BOLSTER FOR A2 CLAMP-DIE
A2	CLAMPING DIE ON BACKSTOP/BOLSTER
B I	STROKER FOR BACKSTOP/BOLSTER [B2]
B2	BACKSTOP/BOLSTER FOR B3 CLAMP-DIE
B3	CLAMP-DIE ON B2 BACKSTOP/BOLSTER

FOUR EXTERNAL HYDR. PRESSES [UPSTROKING]

C	HYDRAULIC PRESS FOR TRAILING EDGE
Mc1	BOLSTER WITH PRESS DIE FOR ABOVE
D	HYDRAULIC . PRESS FOR LEADING EDGE
D I	BOLSTER WITH PRESS DIE FOR ABOVE
E	HORIZONTAL SHELL SHUNTING PRESS
F	HYDRO-LIFT FOR ANGULAR POSITIONING

OTHER ITEMS

G	WHEEL SUSPENSION
H	HYDRAULIC JACK SYSTEM OVER RAILS
J	MAIN POWER CABLE REEL-MOTORIZED
K	ENCLOSURE - ELECTRICITY SUPPLY
L	HYDRAULIC POWER PACK COMPLETE
M	TACK WELDER'S SLIDING SEATS

THE SHIPYARD CROCODILE' IS OF HYDRO-MECHANICAL DESIGN OF ROBUST WELDED STEEL CONSTRUCTION, SELF-PROPELLED ON RAILS AND OPERATES IN CONJUNCTION WITH ITS OWN TURNING ROLL SYSTEM DESIGNED TO FORM AN INTEGRATED PRODUCTION LINE CONTROLLED BY THE OPERATOR OF THE SHIPYARD CROCODILE. FOR THIS PURPOSE, REMOTE CONTROL FACILITY FOR EACH OPERATION THROUGHOUT THE PRODUCTION LINE IS PROVIDED.

THE 'SHIPYARD CROCODILE' CAN BE CLASSIFIED AS A MOBILE WORK-CENTRE, MOVING INTO AND OUT OF THE SHELL ASSEMBLY AREA, ASSISTING PLATERS AND WELDERS. WHEN AND WHERE REQUIRED.

SHIPYARD CROCODILE/ MACHINE TYPE **814.NS.**

THE MACHINE FRAME OF WELDED STEEL CONSTRUCTION TOGETHER WITH ALL PARTS THEREON. IS MACHINED TO ISO-R 230 STANDARD.

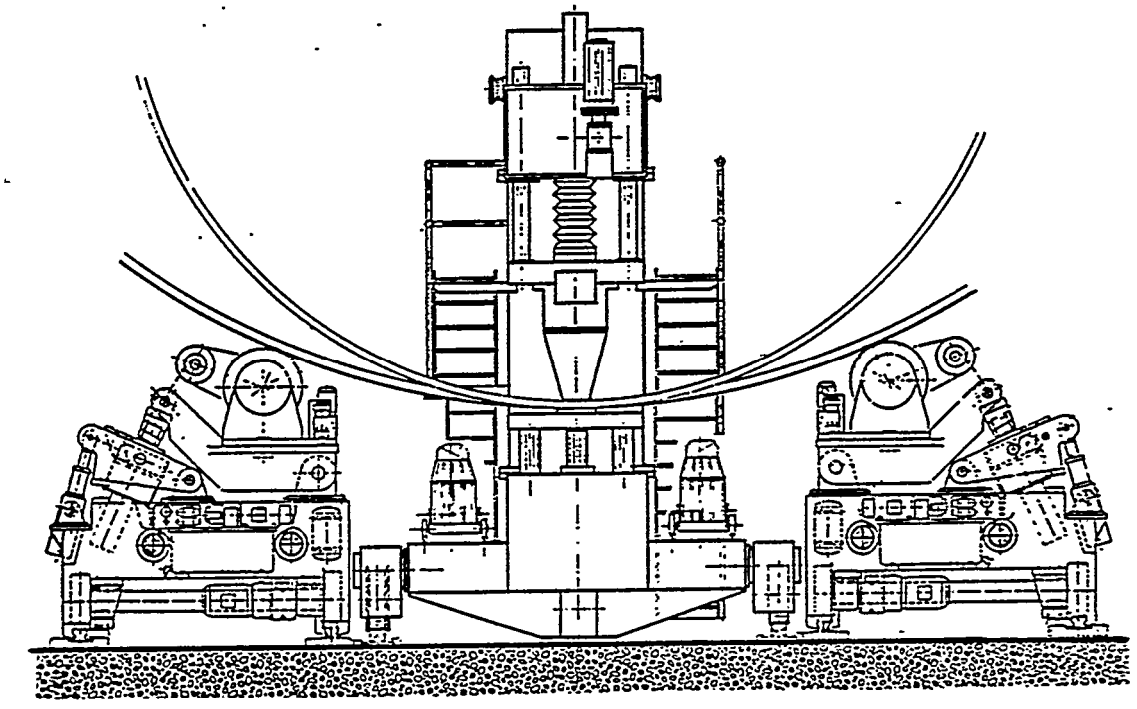
DRIVE ON RAILS
WHEELS, 8 IN NUMBER, ARE FITTED ON 4-SWING CRADLE TYPE SUSPENSION TO SECURE EFFICIENT LOAD DISTRIBUTION. THE GEARED DRIVE AND Transmission IN OIL BATH IS POWERED BY 3-PHASE 2-SPEED ELECTRO-MOTOR TO PROVIDE TRAVELLING AND INCHING SPEED. A SOLENOID OPERATED SPRING LOADED BRAKE SYSTEM IS FITTED TO THE MOTOR FOR POSITIVE POSITIONING AND MAINTAINING SAME ON RAILS.

HYDRAULIC SUB-PRESSES AND HYDRO-MECHANICAL BACKSTOPS
TO CARRY OUT BUTT TO BUTT ASSEMBLY OF CONSECUTIVE SHELL EDGES, 4 HYDRAULIC PRESSES AND TWO HYDRO-MECHANICAL BACKSTOPS ARE APPLIED WITH THE FUNCTIONS AS DESCRIBED ON THE FOLLOWING PAGES.

FOUR HYDRO-MECHANICAL JACKS WITH INTERLOCKED REMOTE CONTROL
ARE FITTED TO ASSIST WHEELS IN LOAD DISTRIBUTION DURING ALIGNING OPERATION BY THE PRESSES.

HYDRAULIC POWER PACK
AT THE END OF THE 'SHIPYARD CROCODILE' IS CONSTRUCTED WITH TWO GEAR PUMPS, ONE WITH 300 AND ONE WITH 30 BAR PRESSURE. IT 1S EQUIPPED WITH A REMOTE CONTROLLED OVERLOAD PROTECTED ELECTRO-HYDRAULIC VALVE SYSTEM. PIPING FROM POWER PACK TO EACH APPLIANCE WHEREVER POSSIBLE 1S IN ONE LENGTH. NOISE LEVEL NOT EXCEEDING 8O DBA.

ELECTRO-HYDRAULIC SWITCH GEAR:
IS IN A SUITABLE ENCLOSURE AND LOCATED AT THE REAR END OF THE 'SHIPYARD CROCODILE'.

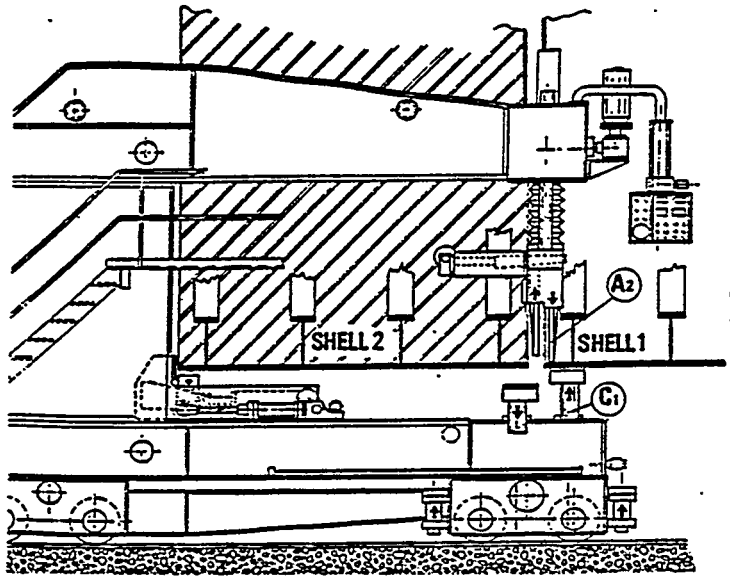


SHIPYARD CROCODILE/ MACHINE TYPE 814.NS.

(WORKING SEQUENCE)

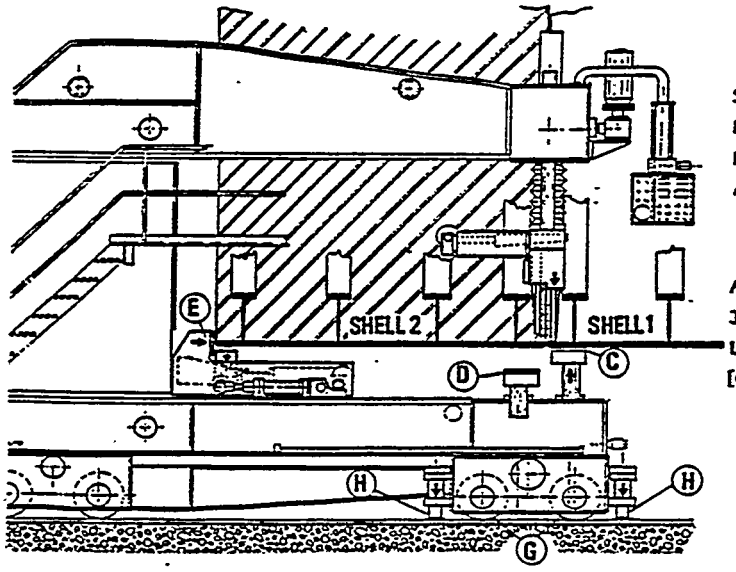
POSITION 'SHIPYARD CROCODILE' INTO ASSEMBLY AREA WITHIN NO.1 & 2 SHELL UNITS, WHICH ARE LOADED ONTO THEIR OWN CARRIAGE MOUNTED TURNING ROLLS.

A



CLAMP TRAILING EDGE OF NO.1 SHELL UNIT BETWEEN THE EXTERNAL PRESS DIE [C1] AND THE INTERNAL BACKSTOP DIE [A2].

B



SHUNT NO.2 SHELL UNIT ON ITS CARRIAGE MOUNTED TURNING ROLLS BY HORIZONTAL PRESS [E] TO ACHIEVE BUTT TO BUTT ASSEMBLY.

AUTOMATICALLY LOWER FOUR HYDRAULIC JACKS [H] TO ASSIST FRONT WHEELS [G] IN LOAD CARRYING WHEN HYDRAULIC PRESSES [C & D] ARE IN USE.

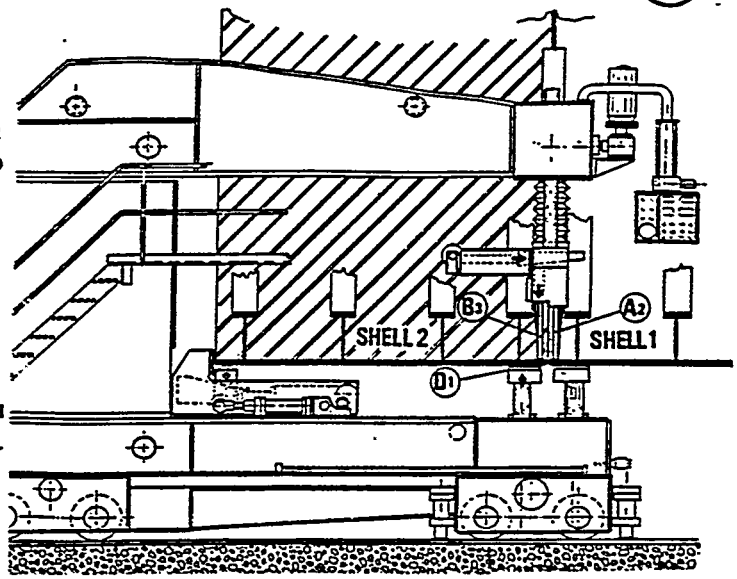
SHIPYARD CROCODILE/ MACHINE TYPE 814.NS.

(WORKING SEQUENCE)

C

CLAMP LEADING EDGE OF SHELL NO.2 BETWEEN EXTERNAL PRESS DIE [D1] AND INTERNAL BACKSTOP DIE [B3]

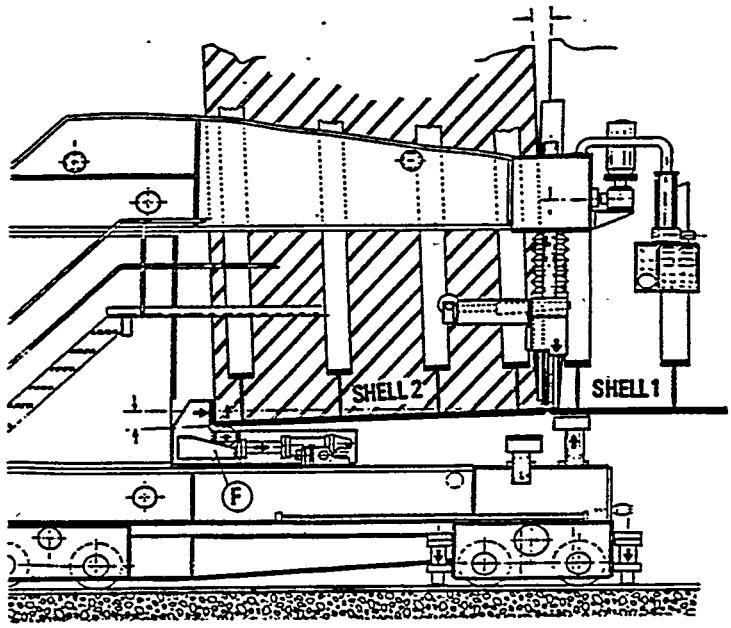
ALIGN TRAILING AND LEADING EDGES WITH EXTERNAL PRESSES [C & D] AND INTERNAL BACKSTOPS [A2 & B3].



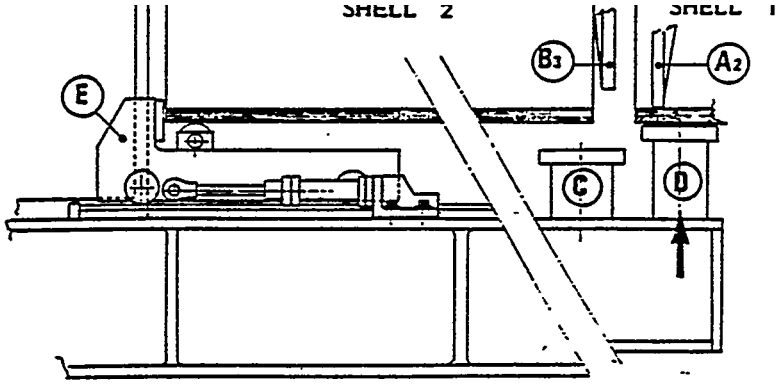
D

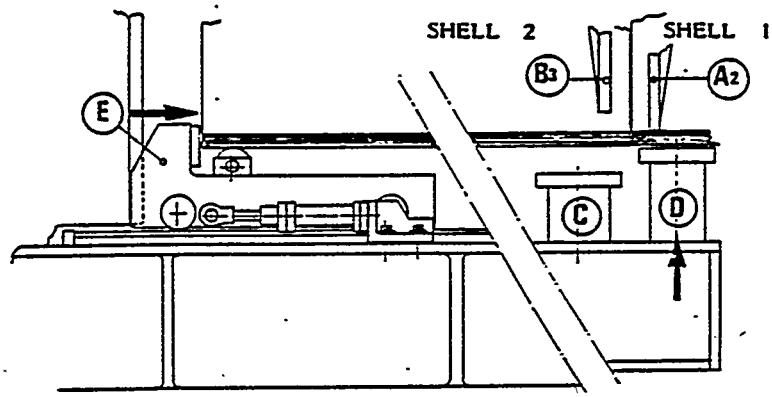
OPERATE HYDRO-LIFT [F] IF SHELL UNIT NO.2 IS NOT IN HORIZONTAL POSITION ON ITS CARRIAGE MOUNTED TURNING ROLLS.

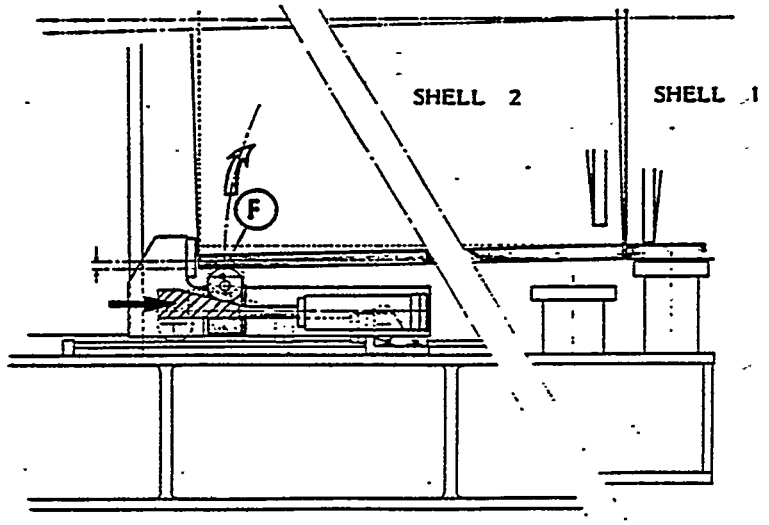
THE SIMULTANEOUS RE-ALIGNMENT OF TURNING ROLLS IS INSTANTANEOUS.



SHIPYARD CROCODILE/ MACHINE TYPE 814.NS.
(WORKING FUNCTIONS)

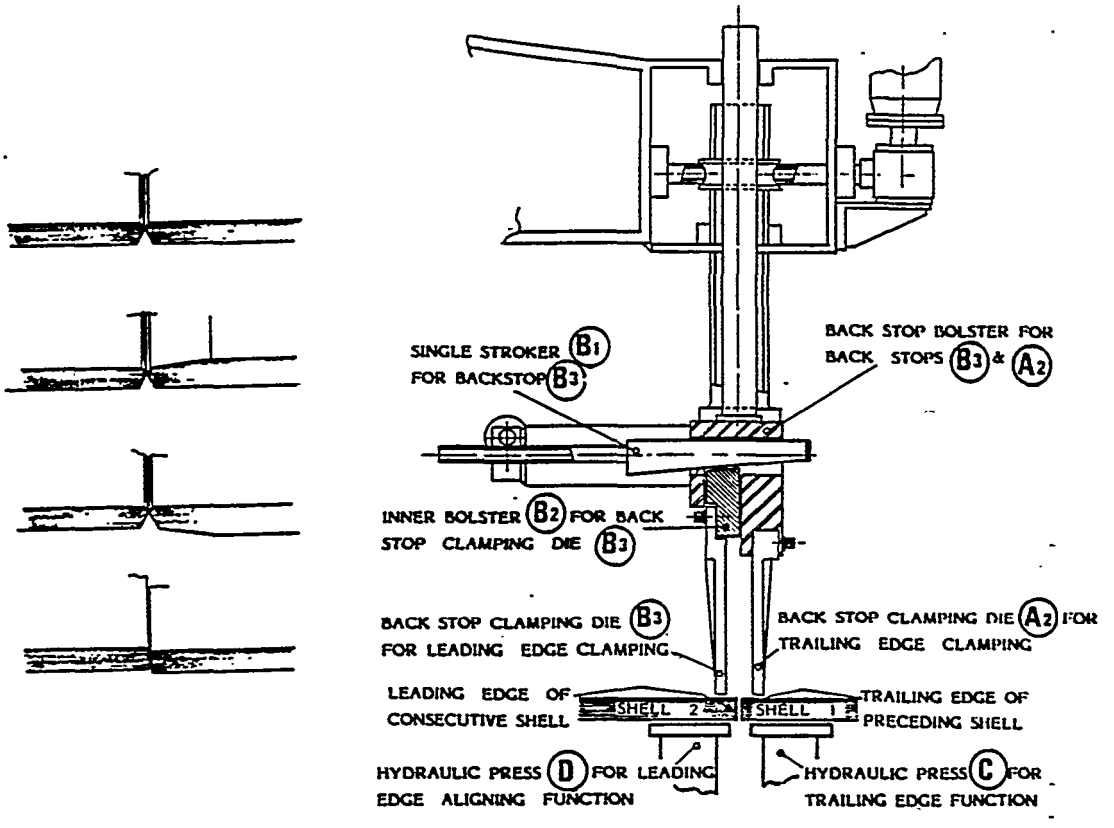






SHIPYARD CROCODILE/ MACHINE TYPE 814.NS.

(WORKING FUNCTIONS)



TWO EXTERNAL UP-STROKING PRESSES C & D IN CONJUNCTION WITH THE INTERNAL BACKSTOP DIES A2 & B3 WILL ALIGN CONSECUTIVE SHELL EDGES WTIHIN THE REQUIREID RELATIVE POSITIONS.

ONE HORIZONTAL PRESS E TO SHUNT SHELL UNIT ON CARRIAGE MOUNTED TURNING ROLLS WITH CARRIAGE BRAKES, DRIVE CLUTCHES AND RAIL CLAMPS OFF. AGAINST SHELL UNIT FOR UNITS ON CARRIAGE MOUNTED TURNING ROLLS WITH CARRIAGE BRAKE, DRIVE CLUTCHES AND RAIL CLAMPS ON BUTT TO BUTT ASSEMBLY]

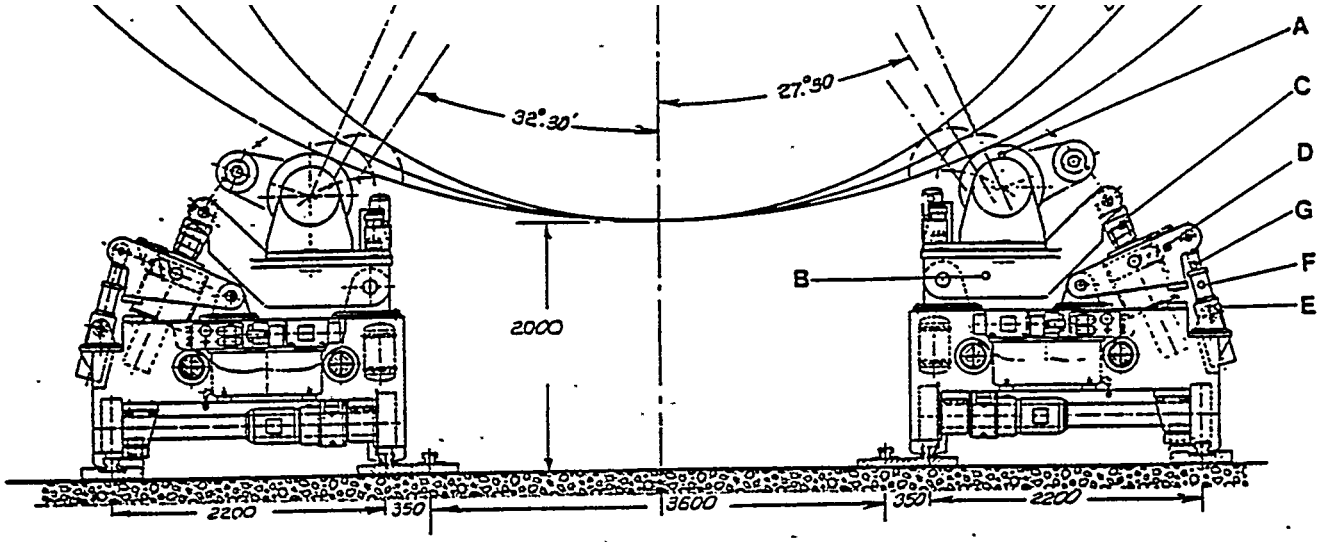
THE HORIZONTAL SHELL UNIT SHUNTING PRESS E HAS A BASIC STROKE OF 400MM. IT CAN BE EQUIPPED WITH INTERCHANGEABLE PUSH-RODS [SPACERS] TO Compensate FOR VARYING SHELL LENGTHS.

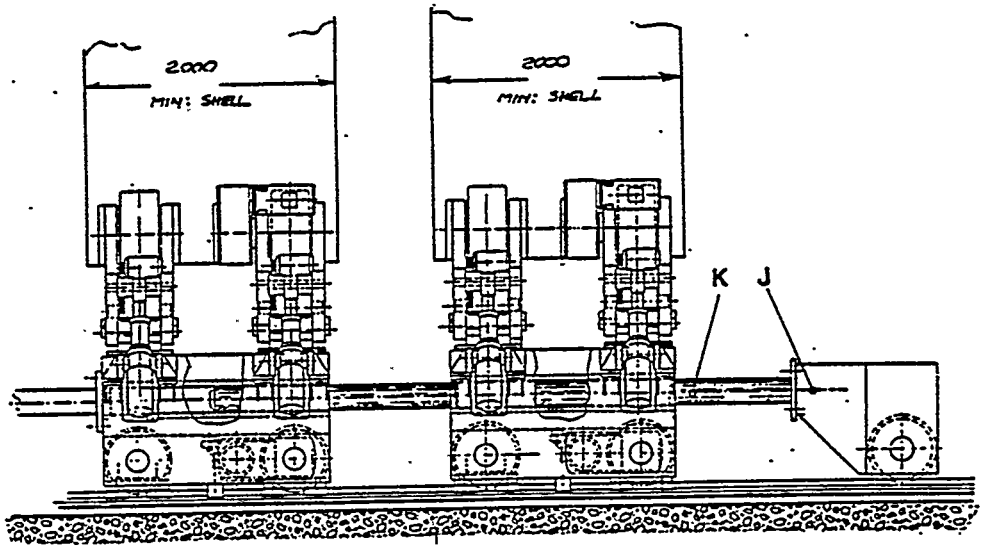
SHELL HYDRO-LIFT PRESS F FOR ANGULAR ALIGNMENT OF SHELL UNIT TO BE ASSEMBLED, THE SIMULTANEOUS RE-ALIGNMENT OF THE RESPECTIVE TURNING ROLLS IS INSTANTANEOUS.

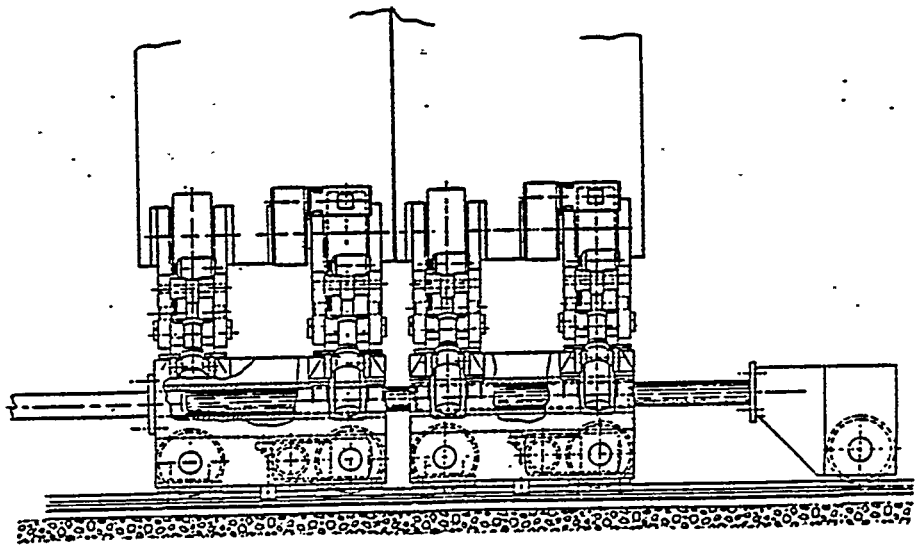
TWO INTERNAL DOWN-STROKING BACKSTOPS - ONE FIXED A2 AND ONE ADJUSTABLE B3 WITHIN THE JOINT STROKING OF SINGLE STROKER B1.

FOUR HYDROMECHANICAL JACKS WITH INTERLOCKED REMOTE CONTROL ARE FITTED TO ASSIST WHEELS IN LOAD DISTRIBUTION DURING ALIGNING OPERATION BY THE PRESSES.

SHIPYARD CROCODILE/ TURNING ROLL SYSTEM







SHIPYARD CROCODILE/ TURNING ROLL SYSTEM

IT SHOULD BE FULLY UNDERSTOOD THAT FOR QUALITY- AND ECONOMY IN PRODUCTION, THE TURNING ROLL SYSTEM IS AN INTEGRAL PART OF THE PRODUCTION LINE PURPOSE BUILT, ESSENTIAL IN DESIGN AND COMPLIMENTARY TO THE FUNCTION OF THE SHIPYARD CROCODILE'. IN OTHER WORDS, A NON-DIVISABLE PRODUCTION EQUIPMENT.

THE TURNING ROWS ARE OF DIVIDED Construction IN PAIRS, I DRIVEN AND I UNDRIVEN ON SELF-PROPELLED CARRIAGES [2 CARRIAGES FORM A SET] ON EACH SIDE oF THE PRODUCTION LINE, WITH ADEQUATE CLEARANCE IN BETWEEN TO GIVE FREE PASSAGE FOR TRANSPORT CARRIAGE FOR SHELL LOADING AND 'SHIPYARD CROCODILE' FOR SHELL ASSEMBLY.

THE BASIC SYSTEM CONSISTS OF 4 SETS OF TURNING ROLLS ON 8 CARRIAGES TO MANIPULATE, TRANSPORT AND ROTATE ONE SHELL OR A SHELL ASSEMBLY. INFINITELY VARIABLE DC DRIVE IS PROVIDED WITH ELECTRONIC REGULATION FOR SYNCHRONIZED REGENERATIVE SPEED THROUGHOUT THE WHOLE TURNING ROLL SYSTEM.

DURING THE SHELL ASSEMBLY WORK THE 'TURNING ROLL SYSTEM' IS INTERLOCKED WITH THE SHIPYARD Crocodile's CONTROLLED BY ITS OPERATOR.

THE TURNING ROLL *SYSTEM IS* CONSTRUCTED TO ACCOMMODATE SHELLS OF VARYING DIAMETERS, WEIGHTS AND NUMBER OF SHELL UNITS TO BE ASSEMBLED.

TURNING ROLLS ON MOTORIZED CARRIAGE CONSIST OF THE FOLLOWING ITEMS .

1: THE WELDED STEEL CASING ON SELF-PROPELLED CARRIAGE ENHOUSING A HYDRAULIC POWER PACK WITH ITS VALVE SYSTEM, REMOTE CONTROLLED FOR EACH AND EVERY OPERATION.

2 TURNING ROLLS ON MECHANICALLY POSITIONED HEAVY CRADLES.

EACH DRIVEN TURNING ROLL IS POWERED WITH INFINITELY VARIABLE SYNCHRONIZED REGENERATIVE TURNING SPEED IN ADDITION TO FAST CLOCK AND ANTI-CLOCKWISE ROTATION.

3 THE HYDRAULIC STROKING Is COMBINED WITH AN INSTANT 'AUTOLOCK' MECHANISM ACTING AS A HYDRO-MeChaniCaI FALL-BACK FOR SAFETY AT WORK.

4: CARRIAGE DRIVE WITH FAST AND INCHING SPEED [FORWARD / IDLING- / REVERSE/BRAKE ON / BRAKE OFF]

5 HYDRO-MECHANICAL RAIL CLAMPS.

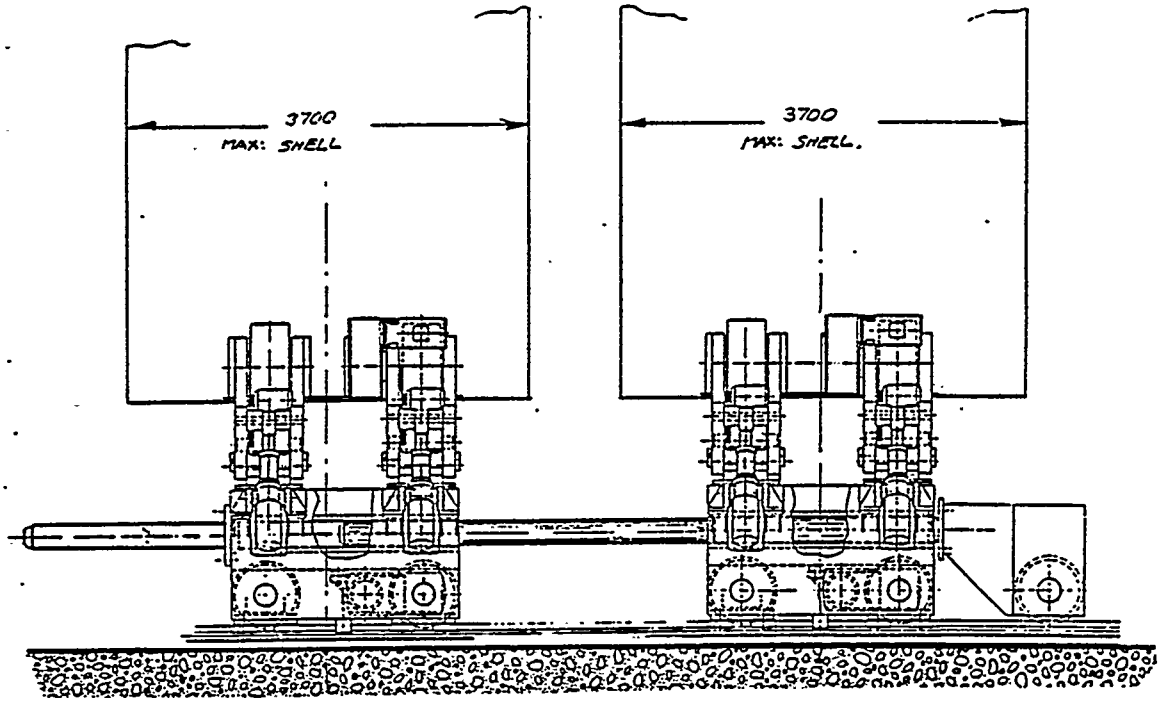
6: GUIDE ROD MECHANISM BETWEEN- CONSECUTIVE CARRIAGES FOR MAXIMUM STABILITY DURING AND AFTER SHELL ASSEMBLY FOR TACK AND CIRC-WELDING OPERATIONS.

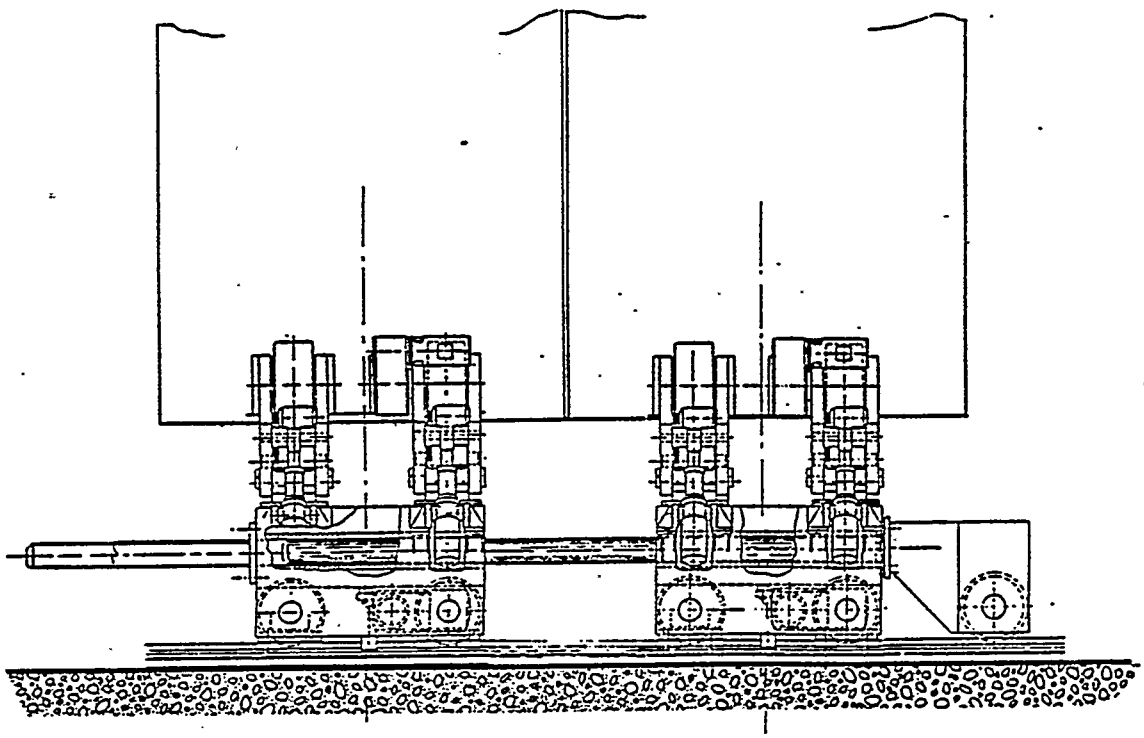
7: SENSOR SYSTEM TO PROVIDE CONTROLLED LONGITUDINAL POSITIONING FOR AND DURING SHELL TRANSFER BETWEEN TRANSPORT CARRIAGE AND TURNING ROLLS.

SEE ILLUSTRATION ON OPPOSITE PAGE

A TURNING ROLL
B TILTABLE CRADLE
C SELF-LOCKING LEAD SCREW
D SWIVEL BRIDGE
E HYDRAULIC CYLINDER
F HYDRAULIC 'AUTO-LOCK'
G HYDRAULIC PISTON
J SATELLITE BOGIE
K TUBULAR GUIDE RODS

SHIPYARD CROCODILE/ TURNING ROLL SYSTEM





SHIPYARD CROCODILE/ TURNING ROLL SYSTEM

THE CASING IS OF WELDED STEEL CONSTRUCTION, WITH RIBBED SECTIONS FOR MAXIMUM RIGIDITY, MACHINED TO ISO-R 230 STANDARD AND SUITABLY BUILT FOR THE EASY FITTING OF:

I : TURNING ROLLS COMPLETE WITH THEIR MECHANICALLY POWERED TILTABLE CRADLES.
2 : HYDRAULIC STROKING AND LOAD BALANCING MECHANISM 'AUTOLOCK'.
3 : MECHANICAL FALL-BACK IN ADDITION TO 'AUTOLOCK'.
4 : HYDRAULICS, ELECTRICS AND ELECTRONICS.

ARRANGEMENT OF TURNING ROLLS:

THE TURNING ROLLS ARE CONSTRUCTED WITH MECHANICAL ROLLER POSITIONING AND HYDRAULIC STROKING. THE TURNING ROLL [A] IS MOUNTED ON A TILTABLE CRADLE [B] AND PRE-POSITIONED BY A SELF-LOCKING LEADSCREW MECHANISM [C] THE LEADSCREW, COMPLETE WITH ITS DRIVE, IS ENHOUSED WITHIN A HYDRAULICALLY ACTUATED SWIVEL CRADLE [D] WHICH PROVIDES HYDRAULIC STROKING ADDITIONAL TO THE MECHANICAL ROLLER 'PRE-POSITIONING. THE LATTER ALSO FACILITATES HYDRAULIC LOAD BALANCING AT ANY ROLLER POSITION AND FOR THIS PURPOSE, THE HYDRAULIC CYLINDER [E] IS CONNECTED *WITH AN* OIL NITROGEN ACCUMULATOR, PROVIDING A FLOAT OF ± 25 MM. THE HYDRAULIC STROKE SETTING AND MAINTENANCE THEREOF IS CONTROLLED BY A HYDRO-MECHANICAL 'AUTOLOCK', OPERATION OF WHICH IS DESCRIBED ON FOLLOWING PAGE.

SPEED AND BRAKE CONTROL

THE SYSTEM GUARANTEES A CONSTANT R.P.M. WHETHER TWO OR ALL EIGHT DRIVEN TURNING ROLLS ARE IN OPERATION OR WHETHER CONCENTRIC OR OFF—CENTRIC LOAD IS TO BE CARRIED AND OPERATES AS FOLLOWS-

AN. OSCILLATING POTENTIOMETER PASSES ON TO THE THYRISTOR CONTROL. THE RATED VOLTAGE VALUE AS REQUIRED. THE ACTUAL VOLTAGE VALUE IS FED BACK VIA A TECHO-DYNAMO BUILT ONTO THE DRIVING MOTOR, COMPARED WITH THE RATED VOLTAGE VALUE OF THE OSCILLATING POTENTIOMETER AND BALANCED IF REQUIRED.

IN ORDER TO MAINTAIN THE POSITION OF AN OUT-OF-BALANCE SHELL OR SHELL ASSEMBLY IN THE STATIONARY STATE EACH MOTOR IS PROVIDED WITH AN ADDITIONAL BRAKE, WHICH CORRESPONDS TO THE RATED TORQUE OF THE DRIVING MOTOR ITSELF.

ANTI-CREEP DEVICE

EACH DRIVEN TURNING ROLL THROUGHOUT THE SYSTEM IS CONSTRUCTED WITH ANTI-CREEP DEVICE WITH PHOTO-ELECTRIC TRACER OVER TAPE ON SHELL.

PRE-SETTING OF HYDRAULIC STROKE

RAISE PISTON [G] WITH AUTOMATIC CONTROL TO 50% OF ITS TOTAL HYDRAULIC STROKE, AT THIS POINT, HYDRAULIC PRESSURE AUTOMATICALLY CUTS-OUT, THUS ACTIVATING 'AUTOLOCK'.

SHIPYARD CROCODILE/ TURNING ROLL SYSTEM

THE 'AUTOLOCK'

THE 'AUTOLOCK' - A PART OF THE HYDRO-CYLINDER - IS A HIGH POWERED CYLINDRICAL CLAMPING DEVICE OVER THE PISTON ROD AND ACTS AS A MECHANICAL FALL—SACK. TO EXPLAIN, A HIGH TENSILE THIN WALLED CYLINDER OF AN INTERNAL DIAMETER LESS THAN THE OUTER DIAMETER OF THE PIST0N ROD IS ASSEMBLED OVER THE LATTER, IN A HOT [EXPANDED] CONDITION AND THUS WHEN COOLED, BECOMES AN EXCEPTIONALLY HIGH POWERED CLAMP.

DURING WORKING AND UNDER HIGH PRESSURE OIL *FLOW,* THE CLAMPING CYLINDER WILL EXPAND GIVING FREE PASSAGE FOR THE PISTON ROD AND WHEN HYDRAULIC PRESSURE B SWITCHED OFF OR FAILS 'AUTOLOCK' CLAMPING SIMULTANEOUSLY ENGAGES.

TURNING ROLL SETTING FOR CIRC-WELDING

THE SETTING OF FOUR TURNING ROLLS, 2 ON EACH END OF THE SHELL OR SHELL ASSEMBLY ARE MECHANICALLY CLAMPED PRIOR TO LOADING BY THE 'AUTOLOCK', PROVIDING ACTUAL POSITIONING OF THE TUBULAR IRRESPECTIVE OF THE NUMBER OF SHELL UNITS ASSEMBLED.

ALL OTHER TURNING ROLLS, ONCE LOADED, ARE FLOATING TO COMPENSATE FOR ANY IRREGULARITIES OF SHELL ASSEMBLY - 'AUTOLOCK' UNCLAMPED.

TO PROVIDE A CONSTANT AND CONTINUOUS LOAD CARRYING OF ALL THE 4 END ROLLS, ONE 'AUTOLOCK~ IS ALSO UNCLAMPED TO ALLOW FLOTATION.

TURNING ROLL SETTING FOR SHELL UNIT LOADING

[DE5CRIPTION OF LOADING - SEE UNDER TRANSPORT CARRIAGE]

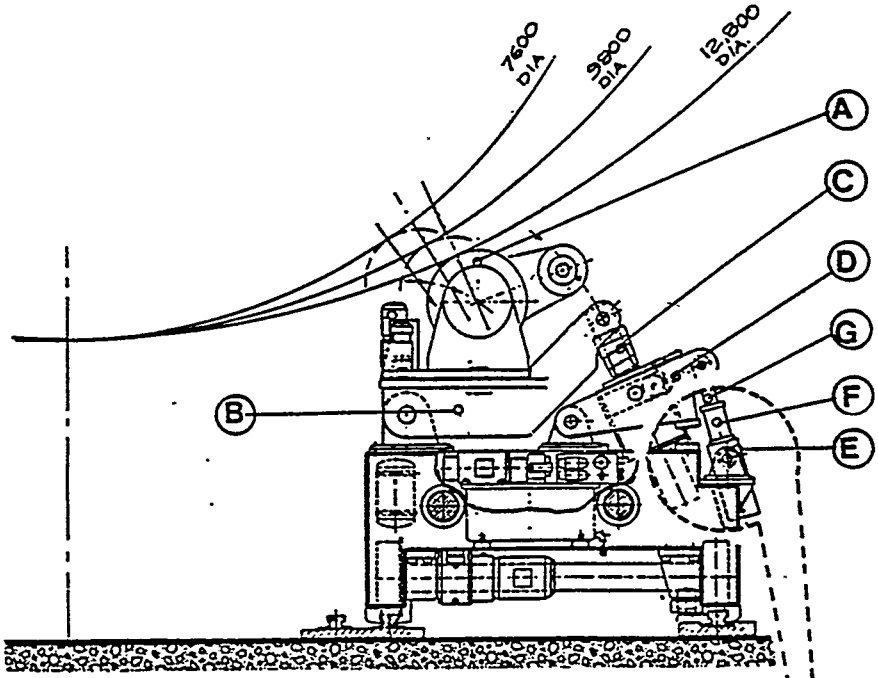
ADDITIONAL STABILITY FOR TURNING ROLLS

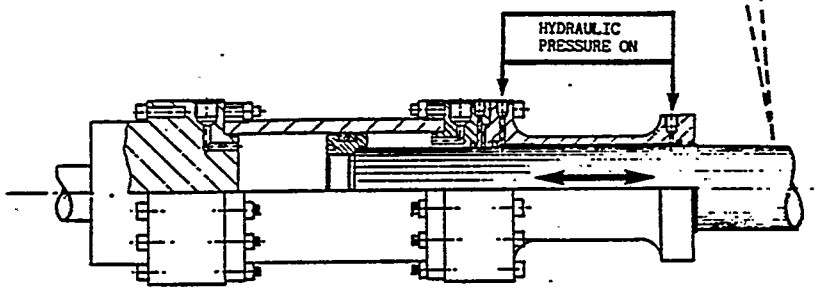
FOR ADDITIONAL STABILITY, EACH TURNING ROLL CARRIAGE IS EQUIPPED WITH HEAVY GUIDE RODS WHICH DOCK INTO THE FOLLOW-ON CARRIAGE THUS FORMING A TURNING ROLL BED OF INCREASED LENGTH AS THE SHELL ASSEMBLY PROGRESSES.

THE FIRST TURNING ROLL CARRIAGE IN THE PRODUCTION LINE, IS DOCKED TO SATELLITE CARRIAGE WITH EXTRA LONG GUIDE RODS,Thus GIVING A MUCH REQUIRED STABILITY DURING LOADING OF FIRST SHELL UNIT.

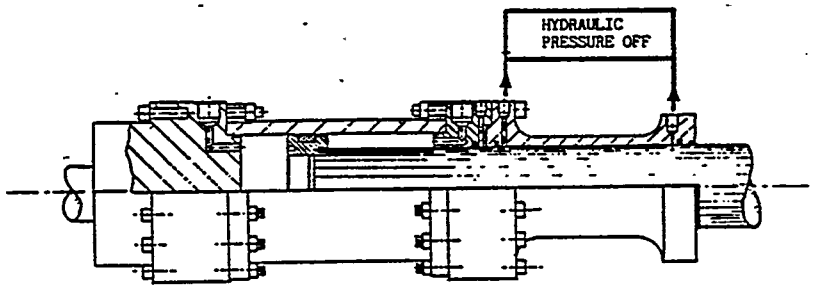
SHIPYARD CROCODILE/ TURNING ROLL SYSTEM

AUTOLOCK



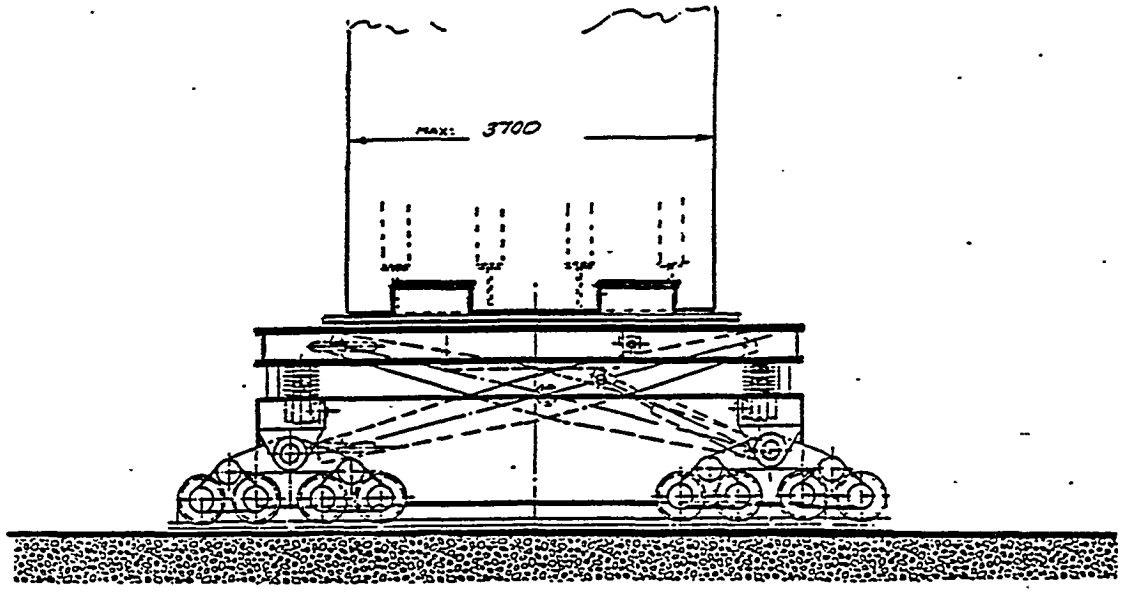


AUTOLOCK CLAMP RELEASED



AUTOLOCK CLAMP ENGAGED

SHIPYARD CROCODILE/ SELF PROPELLED TRANSPORT: CARRIAGE



THE SELF-PROPELLED TRANSPORT CARRIAGE IS DESIGNED FOR THE MAXIMUM SAFETY IN RECEIVING, TRANSPORTING AND TRANSFERRING SHELL FROM CARRIAGE ONTO TURNING ROLLS. THIS 'SAFETY-AT-WORK' IS ACHIEVED NOT ONLY BY THE CARRIAGE CONSTRUCTION ITSELF, BUT BY THE TECHNIQUE APPLIED THROUGHOUT THE WHOLE WORKING SEQUENCE AS DESCRIBED BELOW:-

SET LOADING PLATFORM ON TRANSPORT CARRIAGE TO A POSITION IDENTICAL TO THE OPERATING HEIGHT OF THE TURNING ROLL SET TURNING ROLLS TO CLEARANCE HEIGHT [OPERATION NO. I].

2 : LOAD SHELL BY PURPOSE BUILT CRANE GRAB-MECHANISM ONTO CHOCKS ON LOADING PLATFORM [OPERATION No. i].

3 : TRANSPORT SHELL ON CARRIAGE *TO* TRANSFER L0CATION, LEAVE GRAB-MECHANISM IN POSITION FOR SECURITY. [OPERATION NO. 2].

4 : DRIVE TURNING ROLLS ON SELF-PROPELLED CARRIAGE TO CORRECT SHELL RECEIVING POINT, BY AUTOMATIC LOCATION CONTROL WITH A SENSOR SYSTEM. [OPERATION NO. 3]

AT THIS POINT, SHELL IS ON CHOCKS OF LOADING PLATFORM AT TURNING ROLLS OPERATING HEIGHT, WHILE TURNING ROLLS ARE RETRACTED TO A CLEARANCE HEIGHT BELOW SHELL

5 : TURNING ROLLS ELEVATE FROM CLEARANCE HEIGHT TO EXTERNAL SHELL WALL WITH AUTOMATIC CUT-OUT AT TOUCH *CONTACT* [OPERATION NO. 5]

6 : LOWER TRANSPORT CARRIAGE LOADING PLATFORM TO TRANSFER WEIGHT WITHOUT POSITION CHANGE OF SHELL [SAFETY-AT-WORK. OPERATION NO. 6]

7 : CONTINUE LOWERING LOADING PLATFORM TO FULL CLEARANCE HEIGHT AND DRIVE TRANSPORT CARRIAGE OUT OF TRANSFER AREA [OPERATION NOs. 7 & 8]

SHIPYARD CROCODILE/SELF PROPELLED TRANSPORT CARRIAGE

THE TRANSPORT CARRIAGE IS OF WELDED STEEL CONSTRUCTION WITH AMPLY DIMENSIONED SECTIONS, HYDRO-MECHANICAL POSITIONING OF THE LOADING PLATFORM ALSO INCORPORATING AN INTEGRAL STRONG-SACK SYSTEM OF ENTIRELY MECHANICAL DESIGN, AND CONSISTS OF THE FOLLOWING MAIN COMPONENT&-

1 : CHASSIS WITH SCISSOR TYPE HYDRO-MECHANICAL LOADING PLATFORM POSITIONERS, COUPLED WITH AUTOMATIC STRONG-BACK MECHANISM OF MECHANICAL CONSTRUCTION. SUSPENSION FOR BOGIES, HYDRALIC POWER PACK WITH REMOTE CONTROLLED OPERATING VALVE SYSTEM.

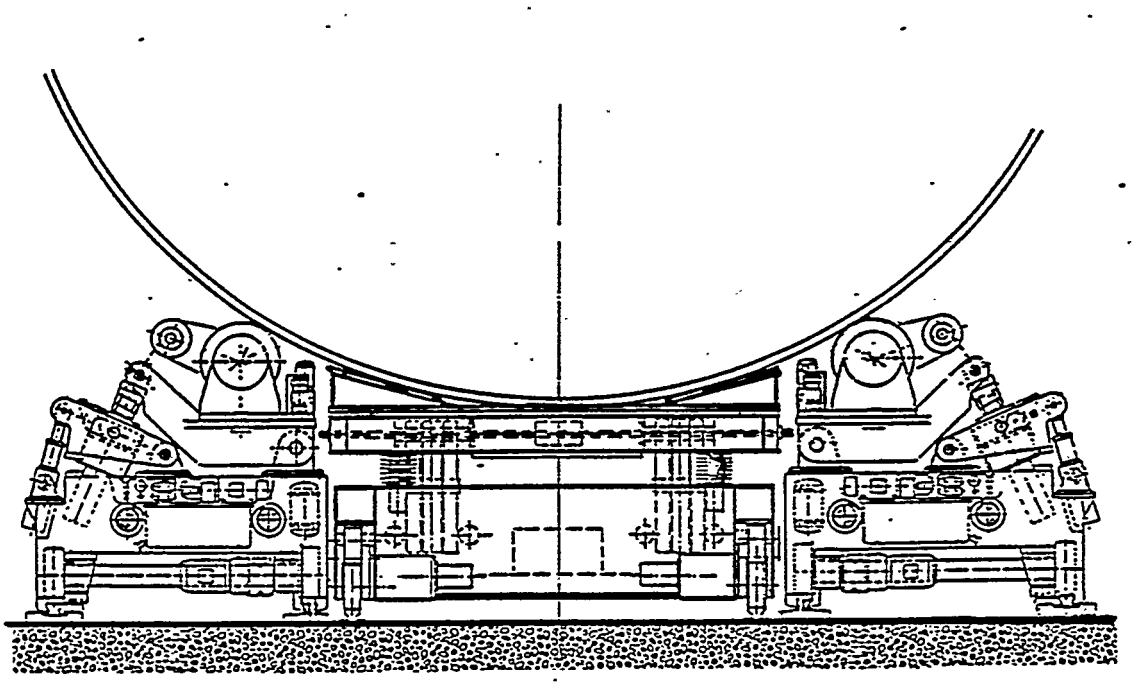
11: BOGIES OF MULTI-PIVOTED MECHANICAL CONSTRUCTION, NUMBER OF WHEELS DETERMINED BY WEIGHT DISTRIBUTION REQUIRED. [ACCEPTABLE LOADING PER LINEAR FOOT.]

THE CHASSIS IS OF WELDED STEEL CONSTRUCTION WITH AMPLY DIMENSIONED SECTIONS FORMING AN INTEGRAL PART OF THE FRAMEWORK AND ENHOUSING THE LOADING PLATFORM WITH ITS SCISSOR TYPE LIFTING SYSTEM AND STRONG-BACK IN THE FORM OF A MULITPLE SCREWJACK MECHANISM.

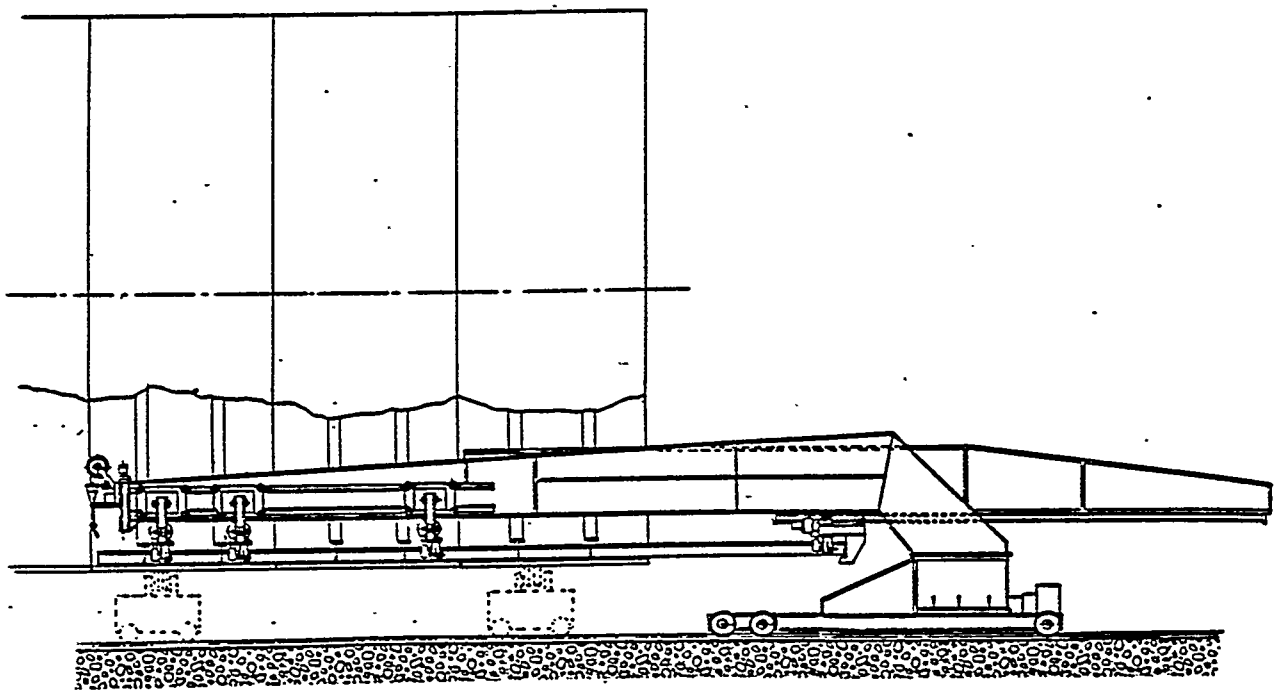
A FULLY SYNCHRONIZED, MULTIPLE POWER DRIVE IS PROVIDED AND A HYDRAULIC POWER PACK WITH REMOTE CONTROLLED VALVE SYSTEM IS INCORPORATED.

THE LOADING PLATFORM IS PRE-POSITIONED TO THE SHELL RECEIVING HEIGHT BY THE HYDRAULICALLY POWERED SCISSOR TYPE LIFTING MECHANISM. ON REACHING THE, REQUIRED SHELL RECEIVING HEIGHT, THE LOADING PLATFORM WILL BE AUTOMATICALLY SACKED-LIP BY A MOTORIZED ,MECHANICAL JACK SYSTEM THUS PROVIDING COMPLETE STRUCTURAL RIGIDITY.

THE CARRIAGE DRIVE CONSISTS OF 4-SW!NG CRADLE SUSPENSIONS WHICH ARE .MOUNTED ON THE CHASSIS JUST AT THE POINTS OF LOADING. EACH CRADLE IS FURNISHED WITH 2 FURTHER SWINGS ON WHICH THE WHEELS [2 ON EACH] ARE MOUNTED. THROUGH THIS ARRANGEMENT THE LOADING IS EVENLY DISTRIBUTED OVER 16 WHEELS. THE ELECTRO-MECHANICAL DRIVE IS ARRANGED FOR FORWARD/NEUTRAL/REVERSE AND PROVIDES ACCELERATION AND DECELERATION TO MAINTAIN BALANCE OF SHELL DURING TRANSPORTATION.

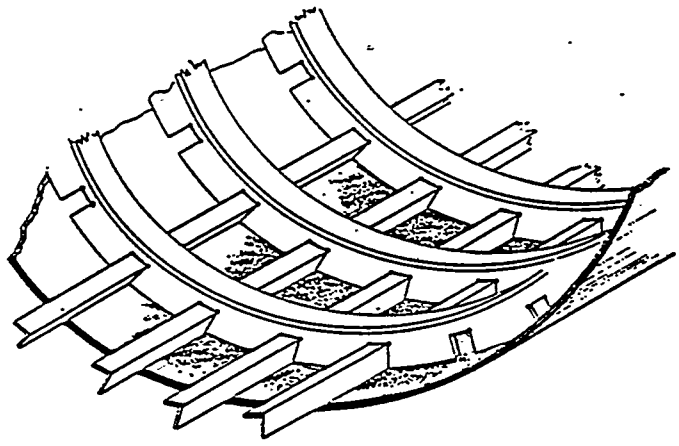


AXIAL REINFORCEMENT PROFILE FEEDER/WELDER



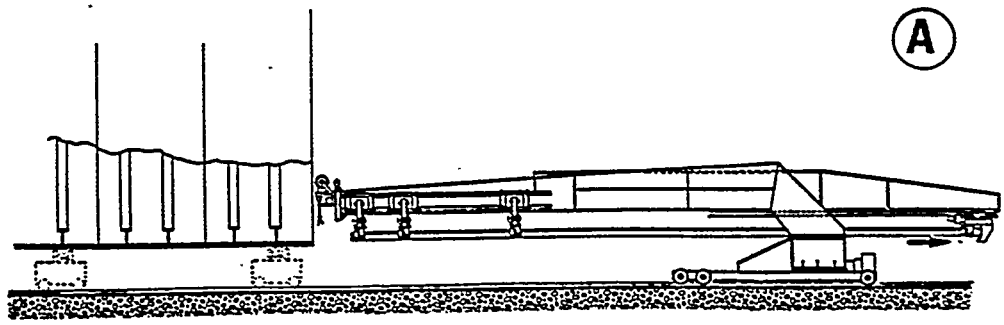
THE EQUIPMENT IS DESIGNED TO FEED STEEL PROFILES FOR AXIAL REINFORCEMENT AND CARRY OUT CERTAIN LONGITUDINAL WELDING OPERATIONS.

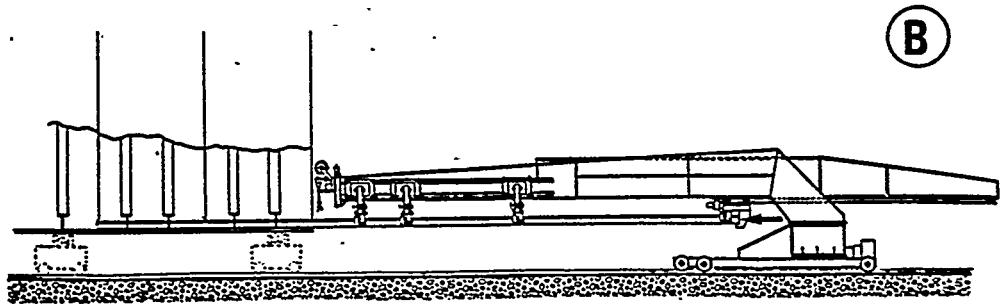
IT IS SELF PROPELLED ON RAILS WITH AN INJECTING MECHANISM FOR THE PROFILE STEEL WITH GUIDES AND SENSORS TO PERFORM SEMI-AUTOMATIC WORK.

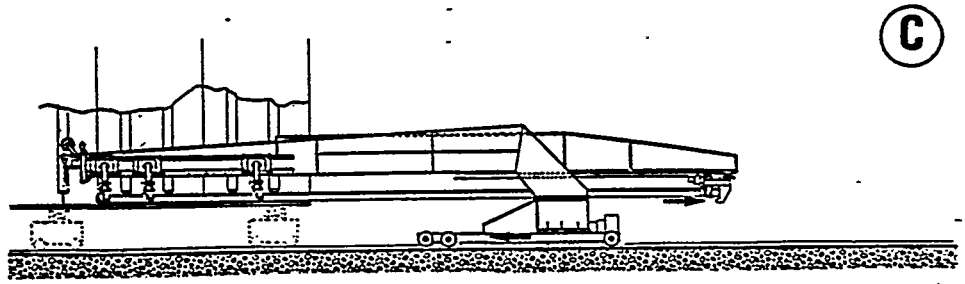


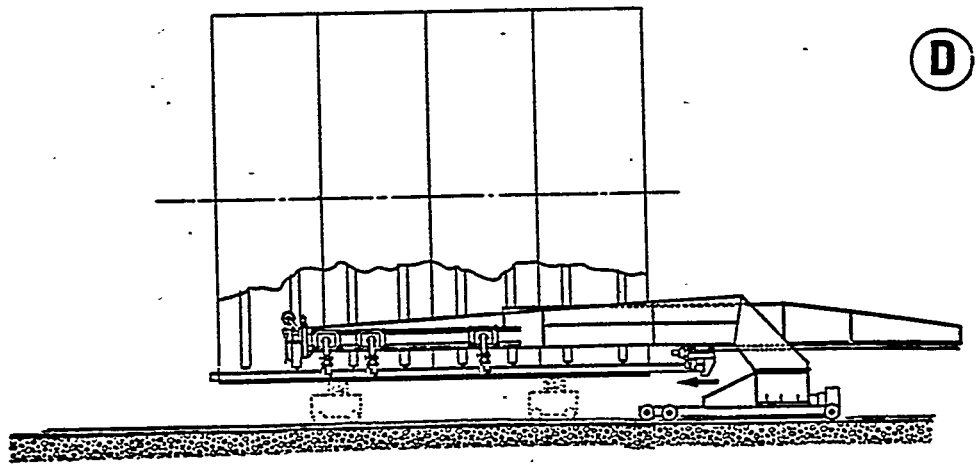
AXIAL REINFORCEMENT PROFILE FEEDER/WELDER

(WORKING SEQUENCE)

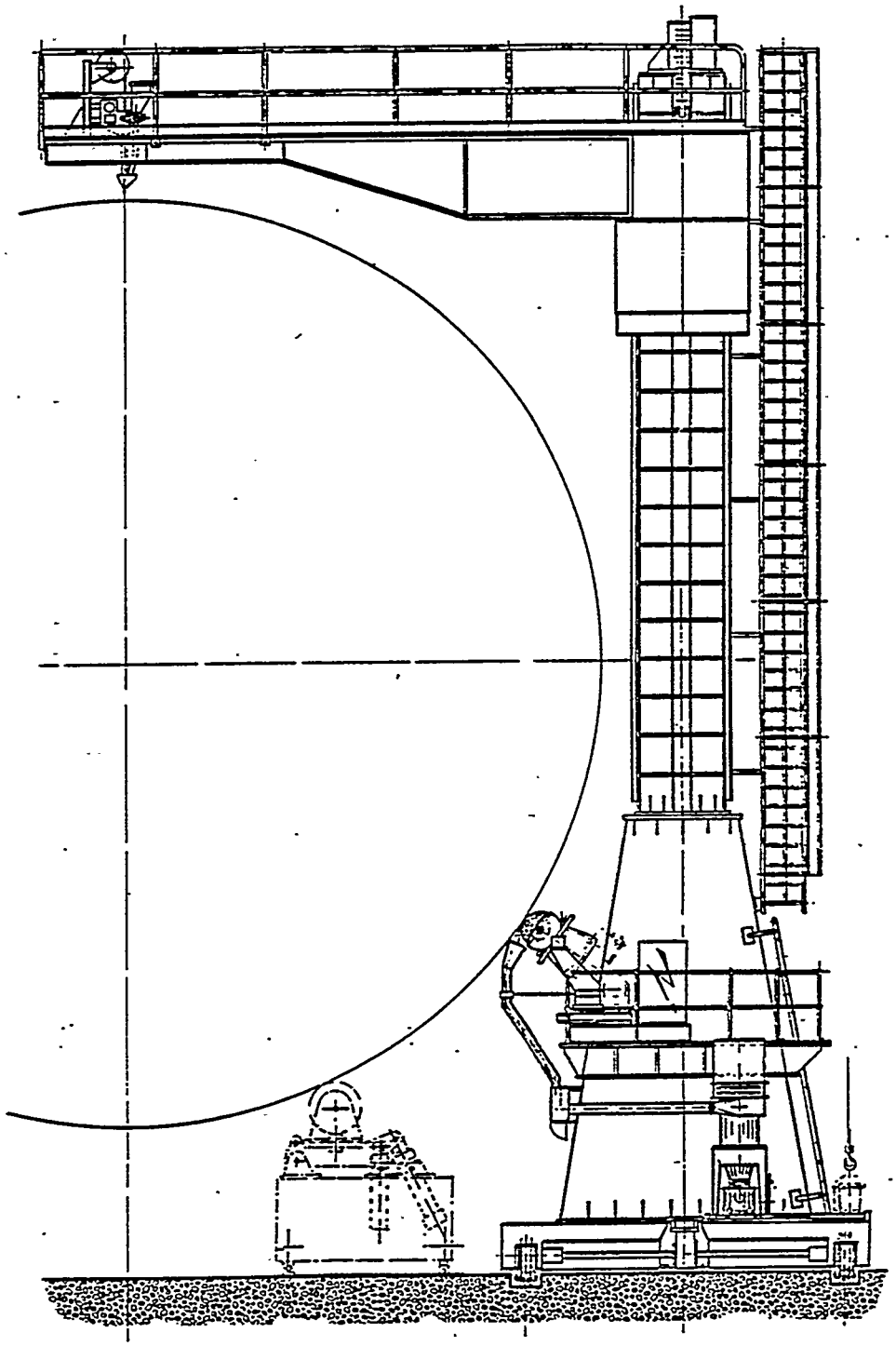








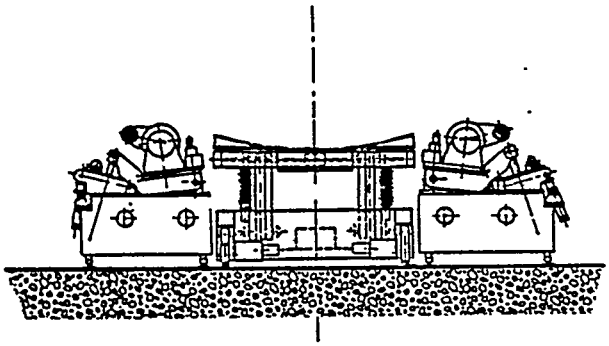
EXTERNAL WELDING BOOM AND BACK GOUGE

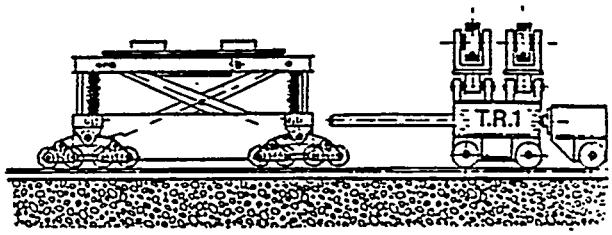


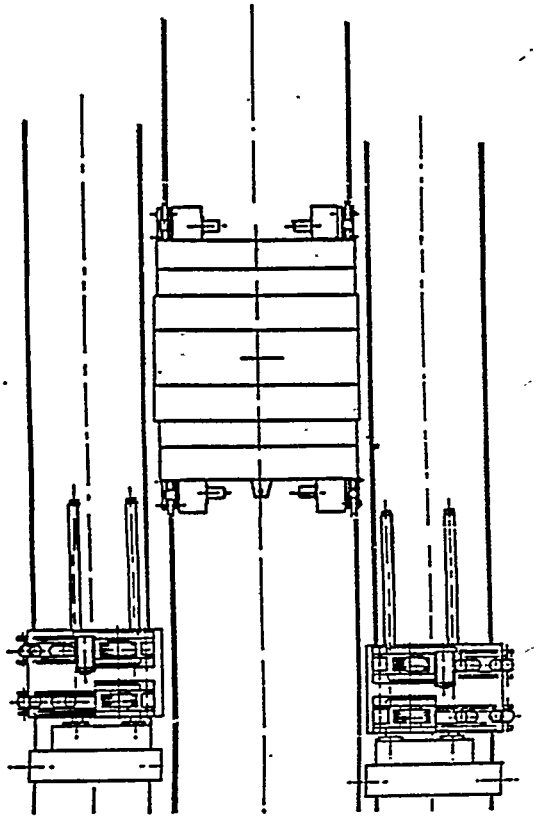
PART II

OPERATION SEQUENCE

OPERATION SEQUENCE







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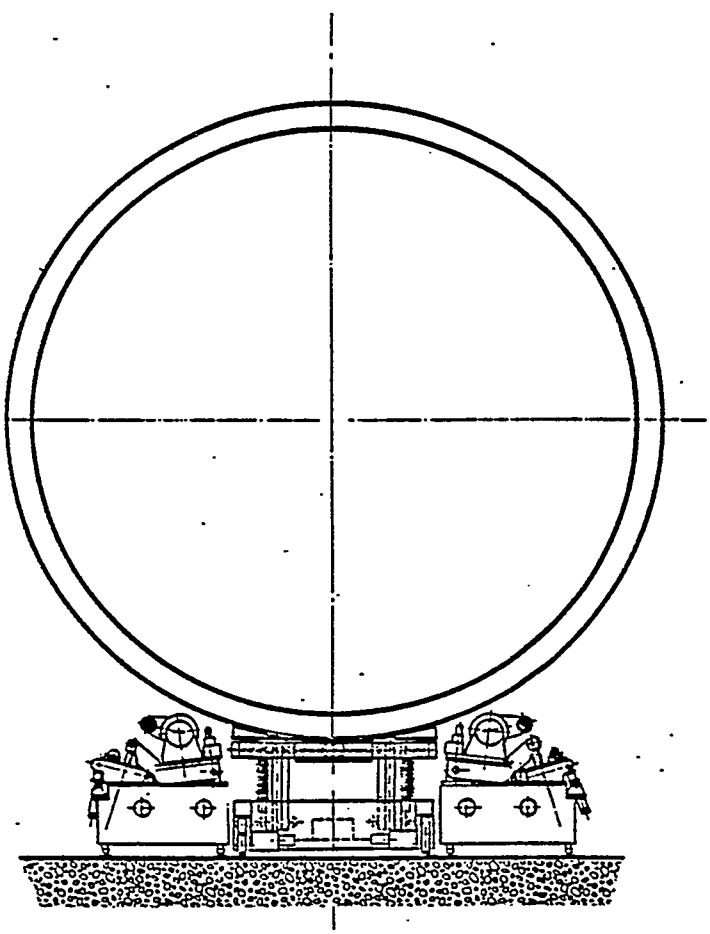
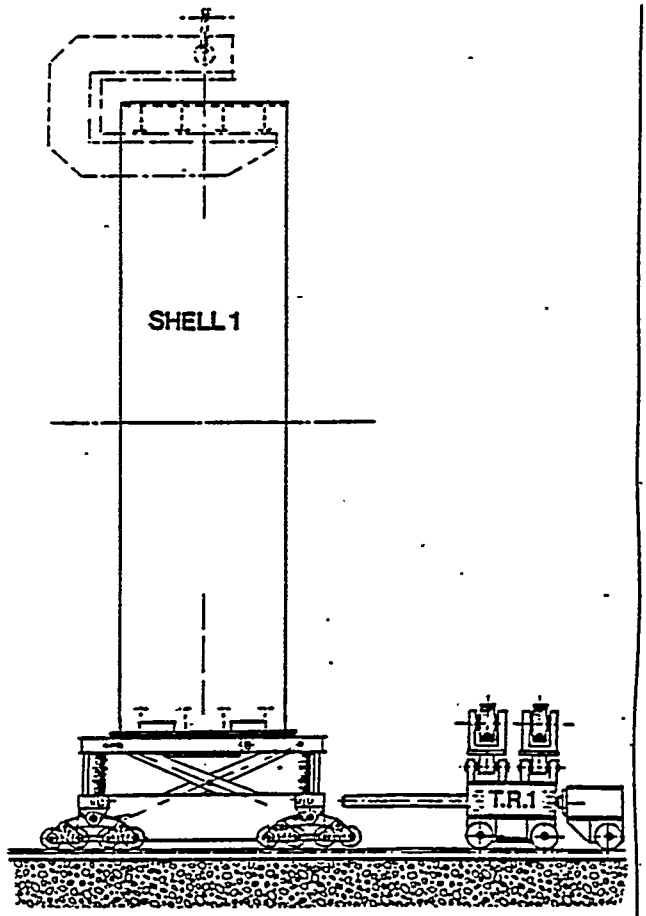
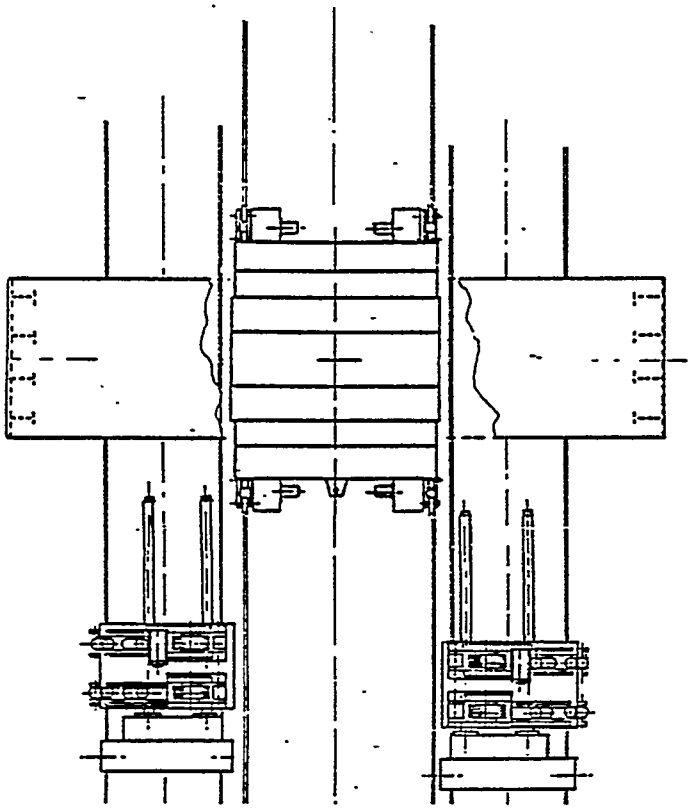




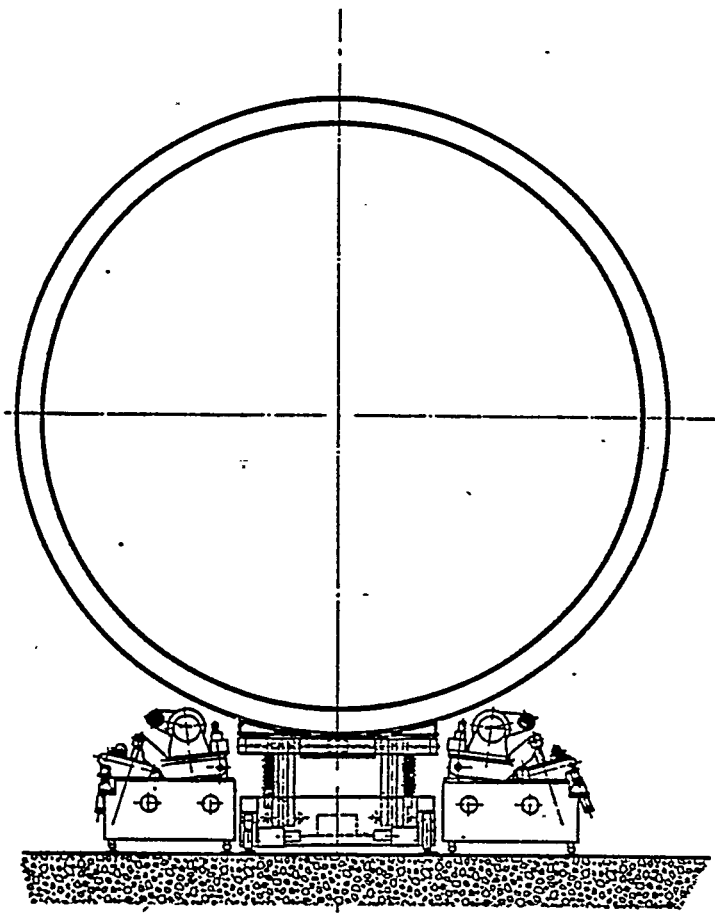


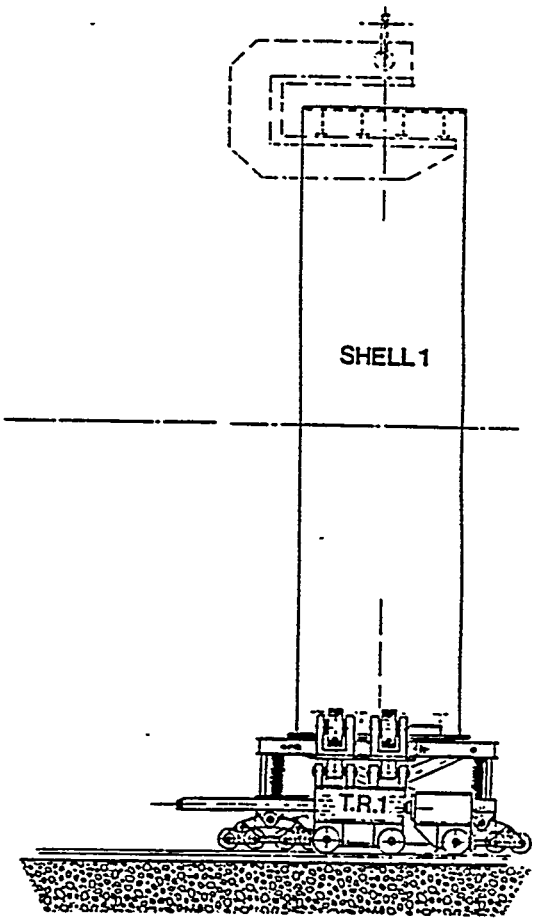
OPERATION 1

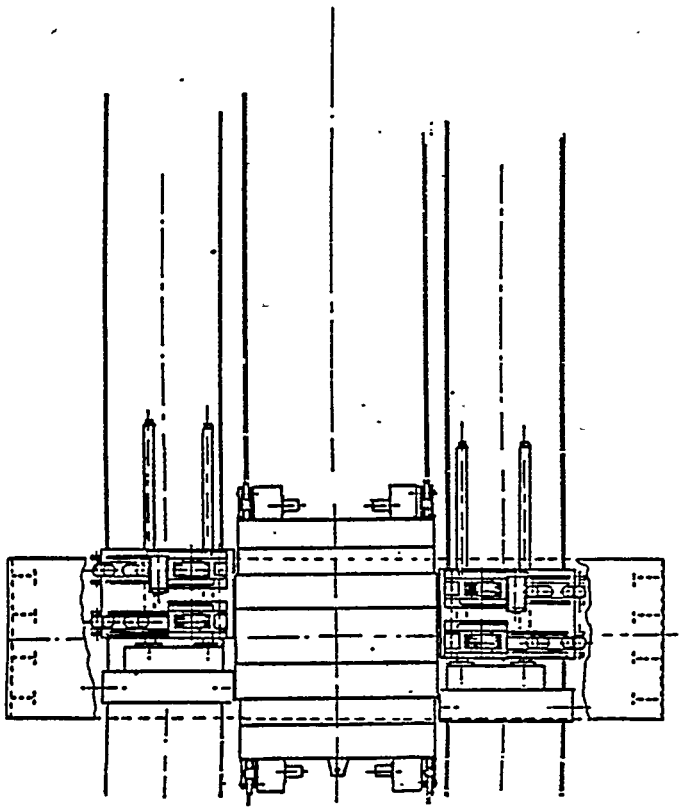
CRANE LOAD TRANSPORT CARRIAGE WITH SHELL1 ONTO CHOCKS ON LOADING PLATFORM SET TO TURNING HEIGHT.

LEAVE PURPOSE BUILT CRANE-GRAB IN POSITION FOR ADDITIONAL SECURITY DURING SHELL TRANSPORTATION AND TRANSFER OPERATION.

OPERATION SEQUENCE



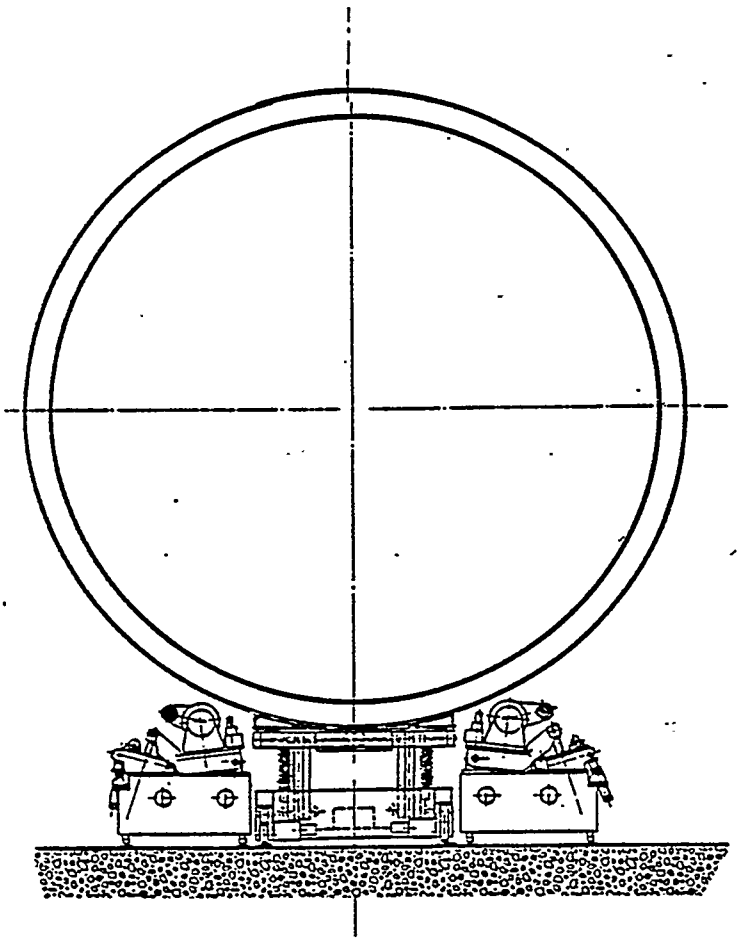


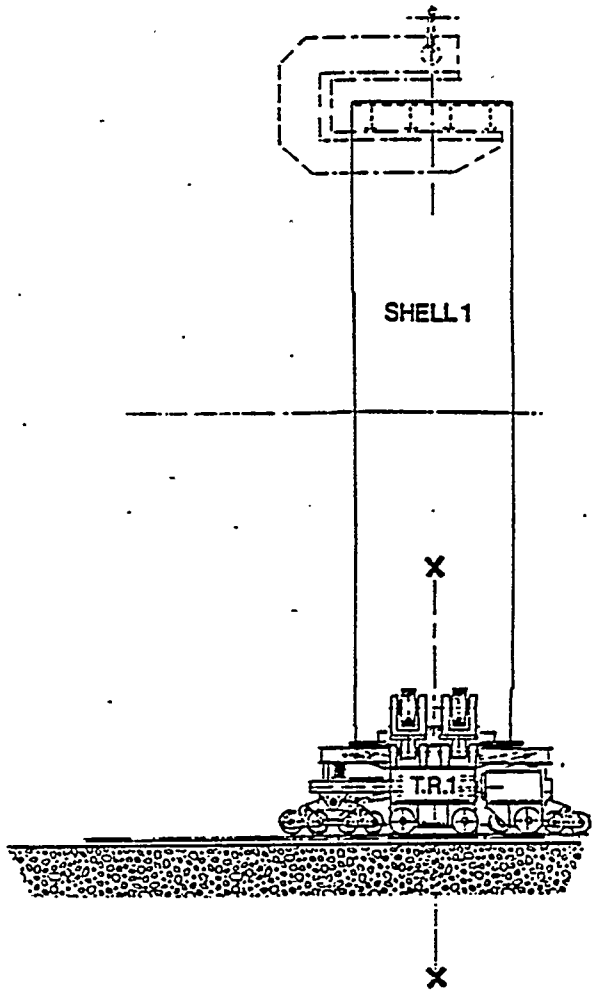


OPERATION 2

SET TURNING ROLLS [TR1 & TR2] TO CLEARANCE HEIGHT AND TRANSPORT SHELL1 BY TRANSPORT CARRIAGE TO PASS SAME INTO TRANSFER LOCATION, THUS ALLOWING OPERATION '3'.

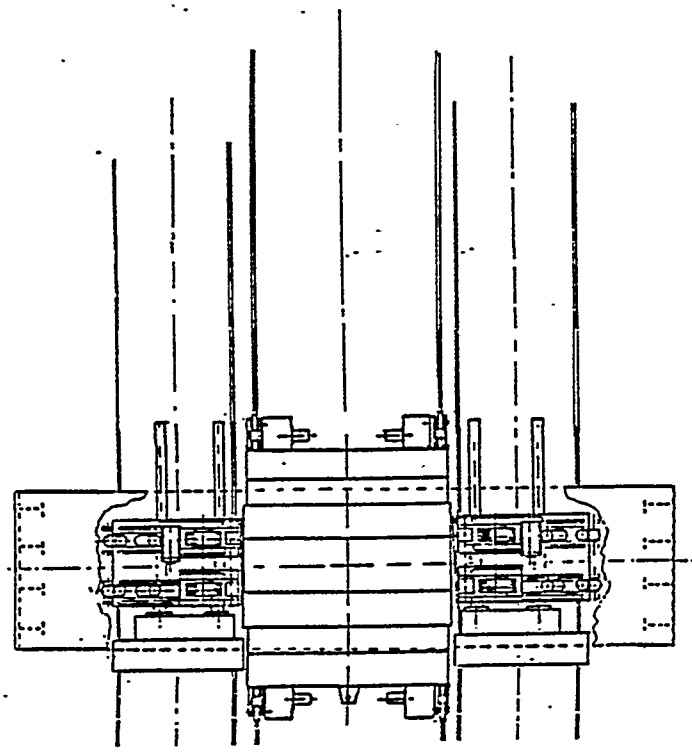
OPERATION SEQUENCE





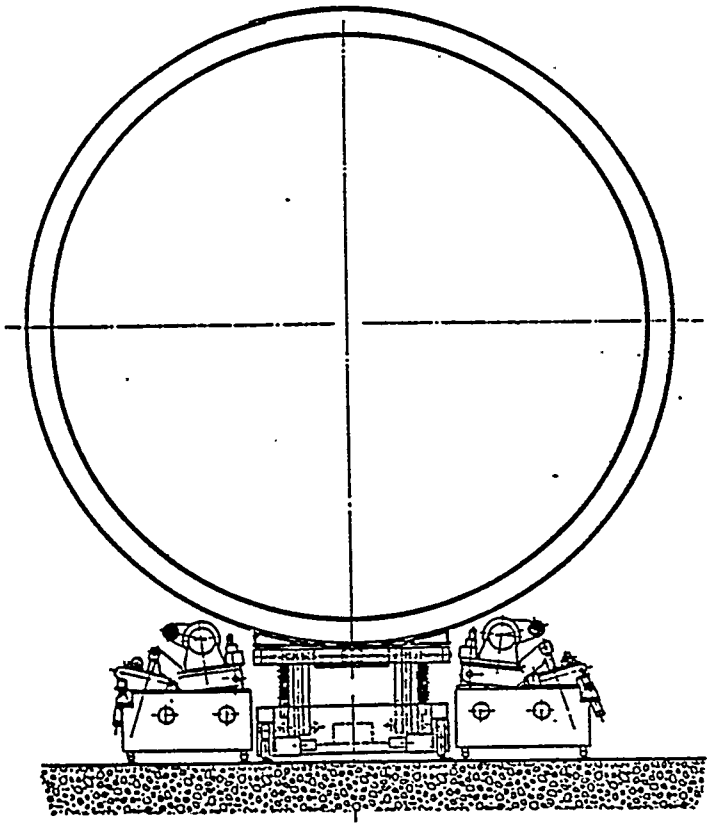
OPERATION 3

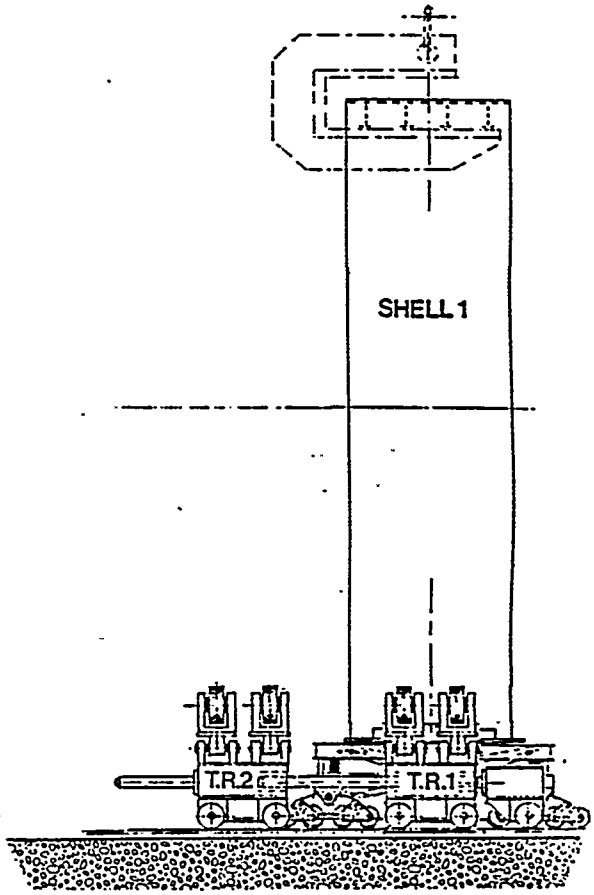
DRIVE SELF-PROPELLED SENSOR CONTROLLED TURNING ROLLS [TR1] AND ITS SATELLITE (J) INTO SHELL TRANSFER POSITION. TURNING ROLLS WILL AUTOMATICALLY STOP.

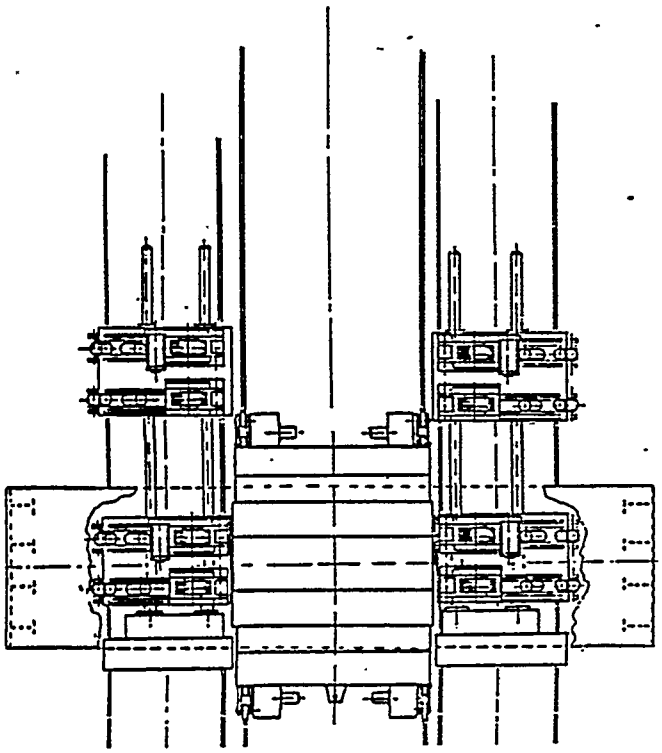


✕ SHOWS THE PRECISION OF SENSOR CONTROLLED
✕ TURNING-ROLL POSITIONING FOR SHELL TRANSFER

OPERATION SEQUENCE



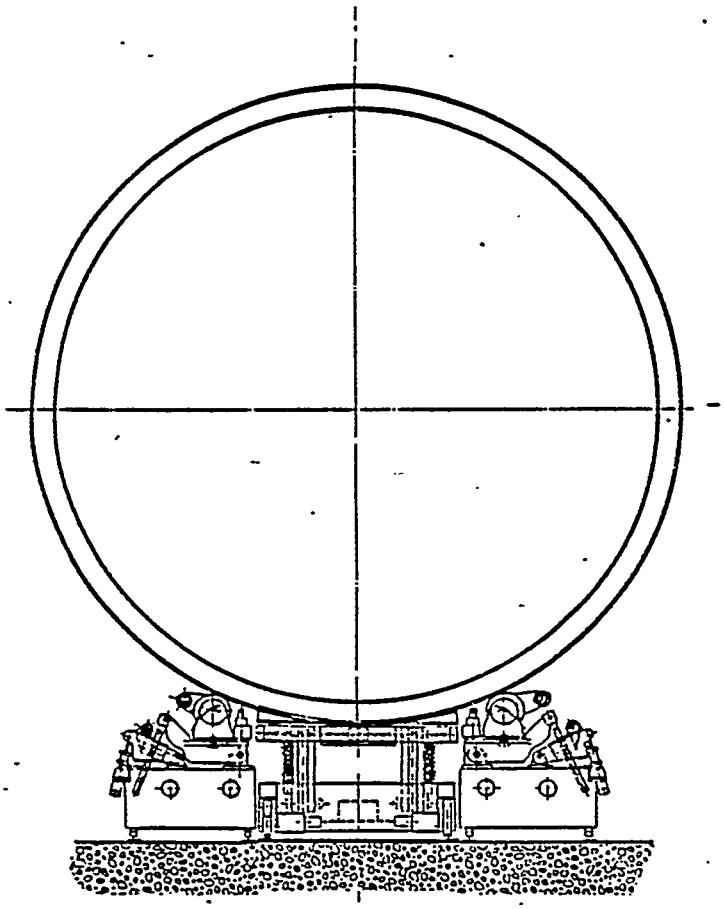


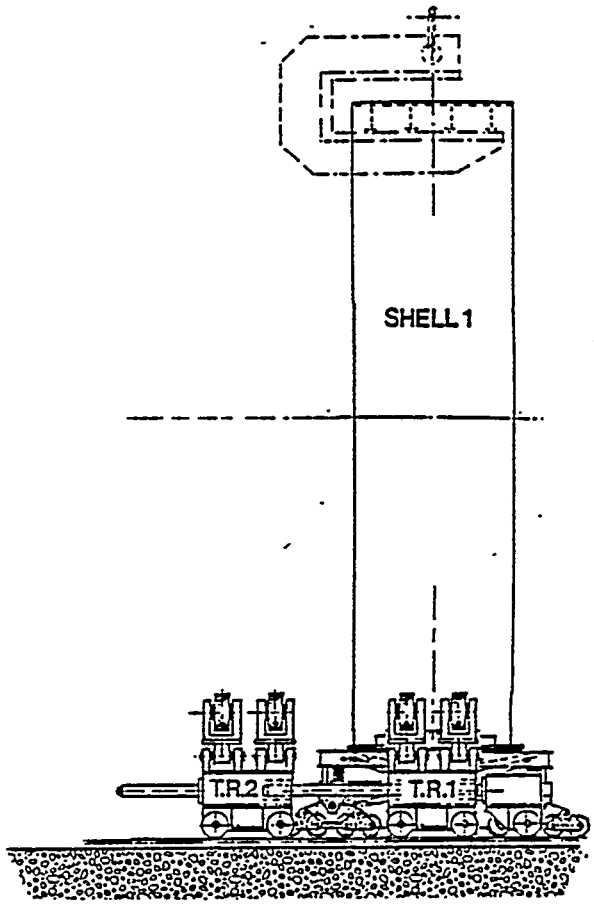


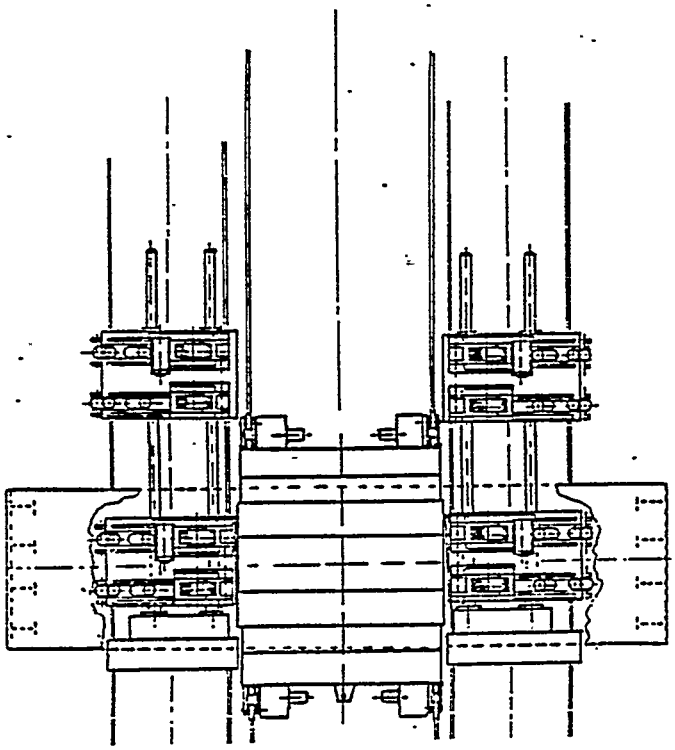
OPERATION 4

DRIVE SENSOR CONTROLLED TURNING ROLLS [TR2]-INTO APPROXIMATE SHELL TRANSFER POSITION WHERE ADDITIONAL STABILITY IS PROVIDED BY THE TUBULAR GUIDING SYSTEM (K) NOW COUPLED.

OPERATION SEQUENCE





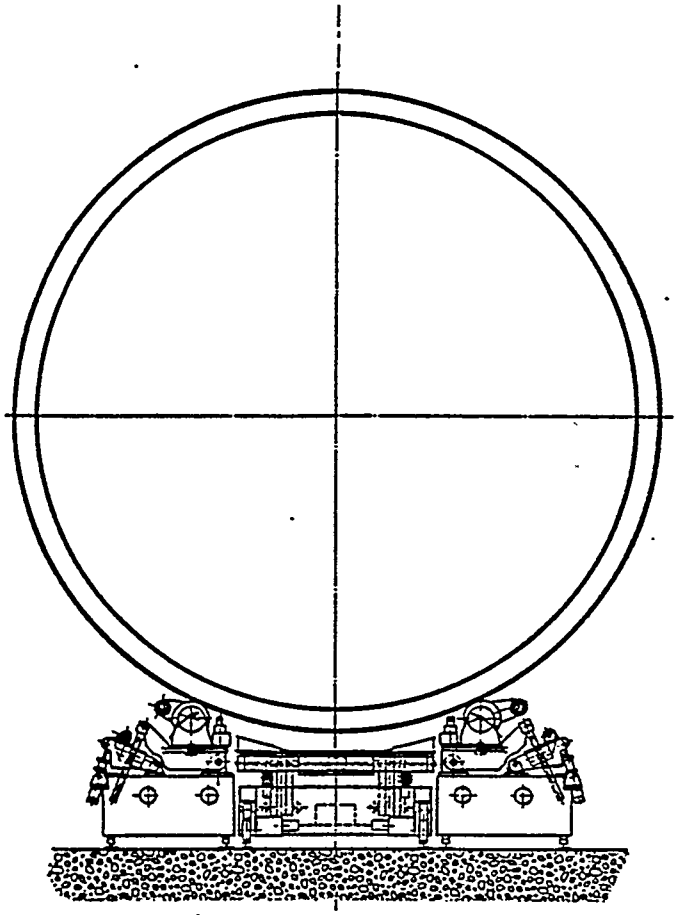


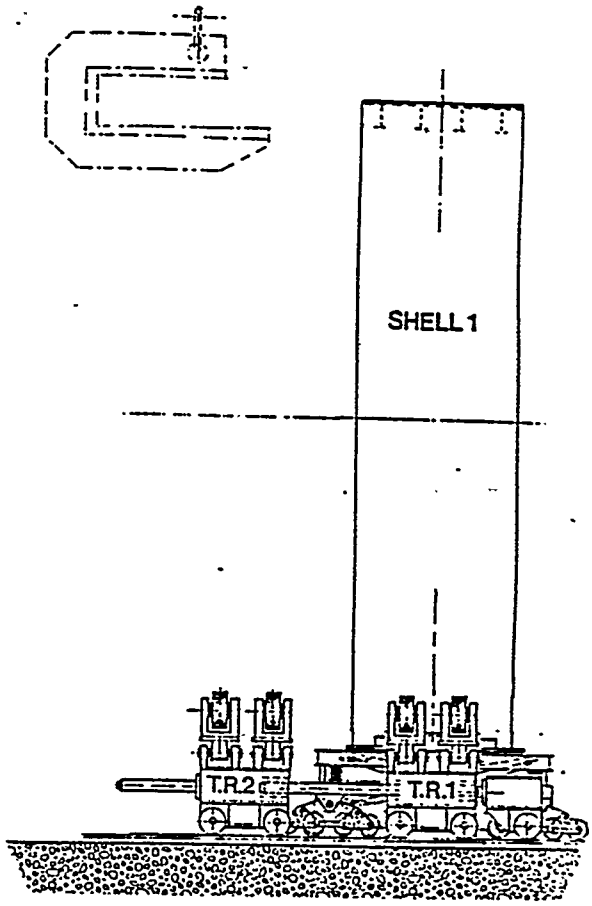
OPERATION 5

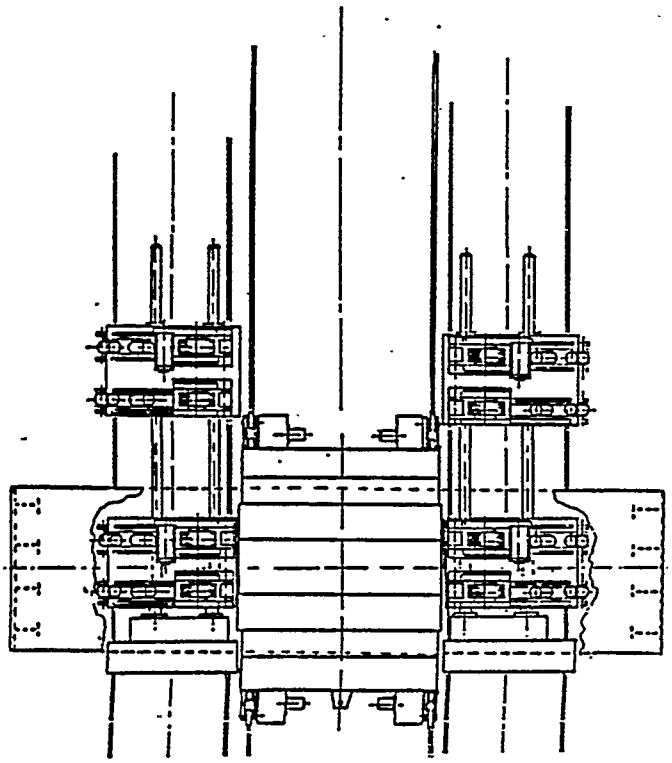
LIFT TURNING ROLLS [TR1] TO TOUCH CONTACT WITH SHELL.

AUTOMATIC CUT-OUT IS PROVIDED.

OPERATION SEQUENCE







OPERATION 6

TRANSFER SHELL1 FROM TRANSPORT CARRIAGE ONTO TURNING ROLLS [TR1] ALREADY IN TOUCH CONTACT.

[LOAD TRANSFER ONLY WITHOUT SHELL MOVEMENT].

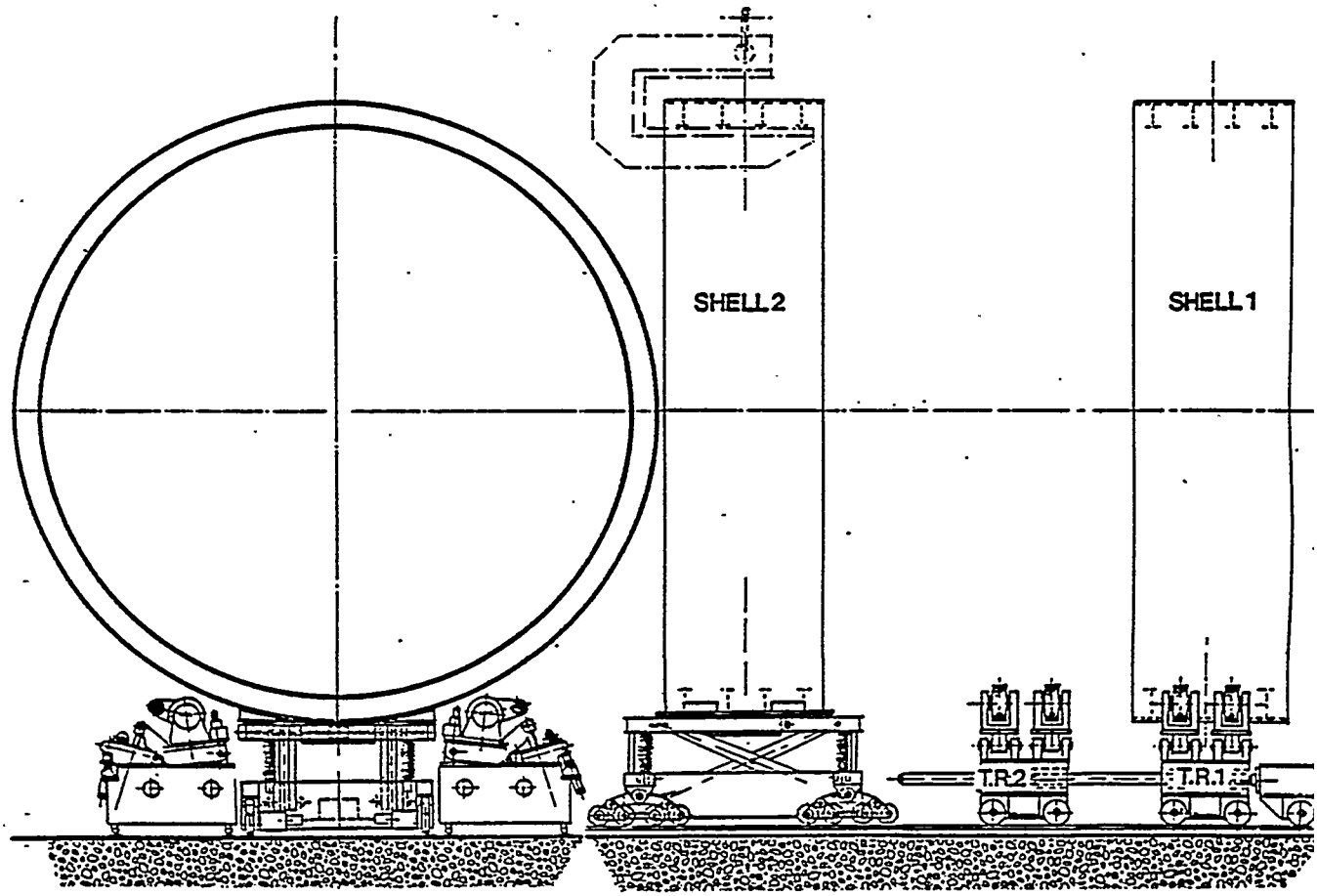
OPERATION 7

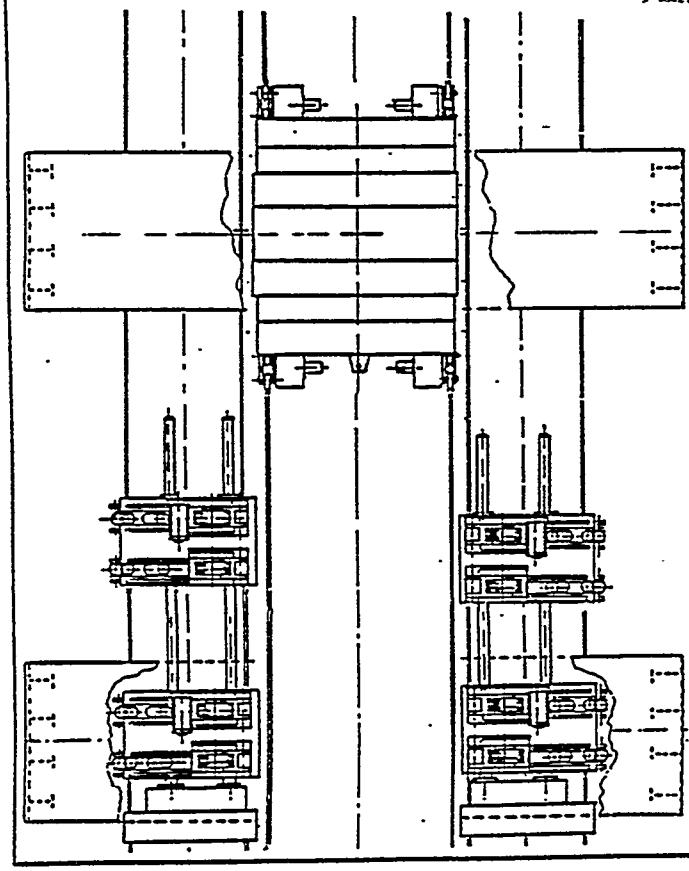
CONTINUE LOWERING TRANSPORT CARRIAGE-LOADING PLATFORM TO CLEARANCE HEIGHT AND DRIVE TRANSPORT CARRIAGE OUT OF TRANSFER AREA.

OPERATION 8

REMOVE CRANE-GRAB.

OPERATION SEQUENCE

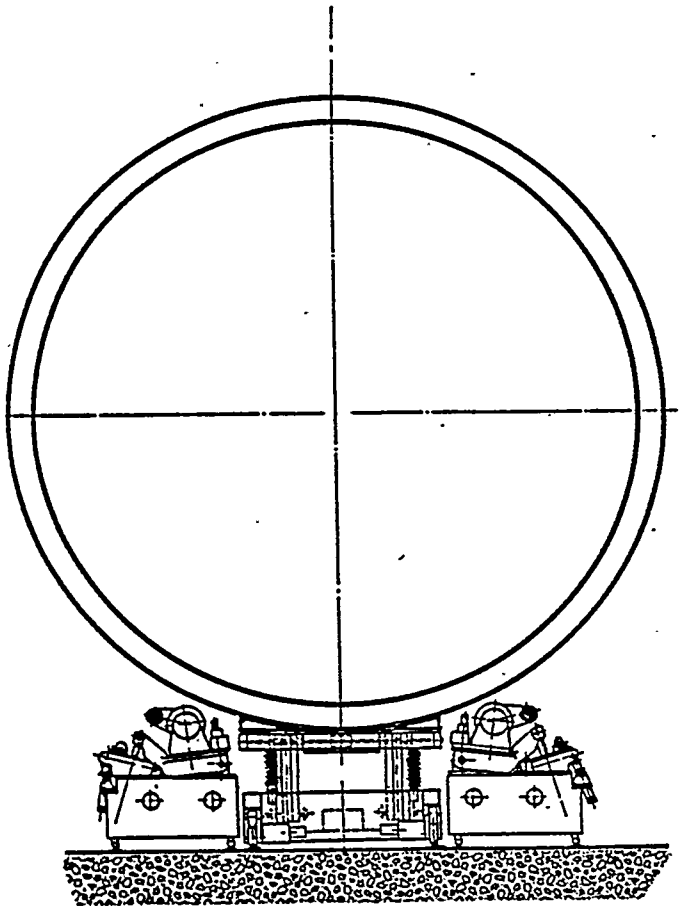


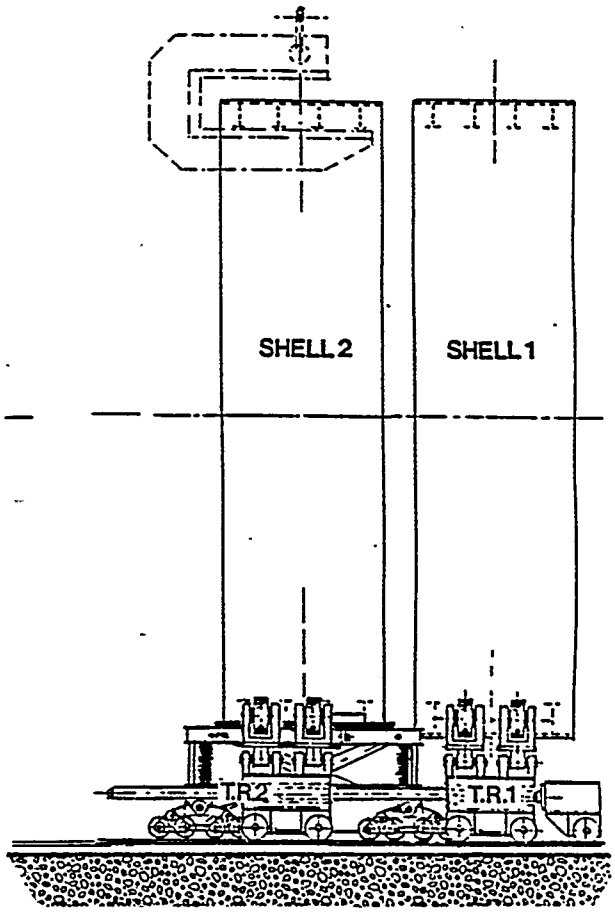


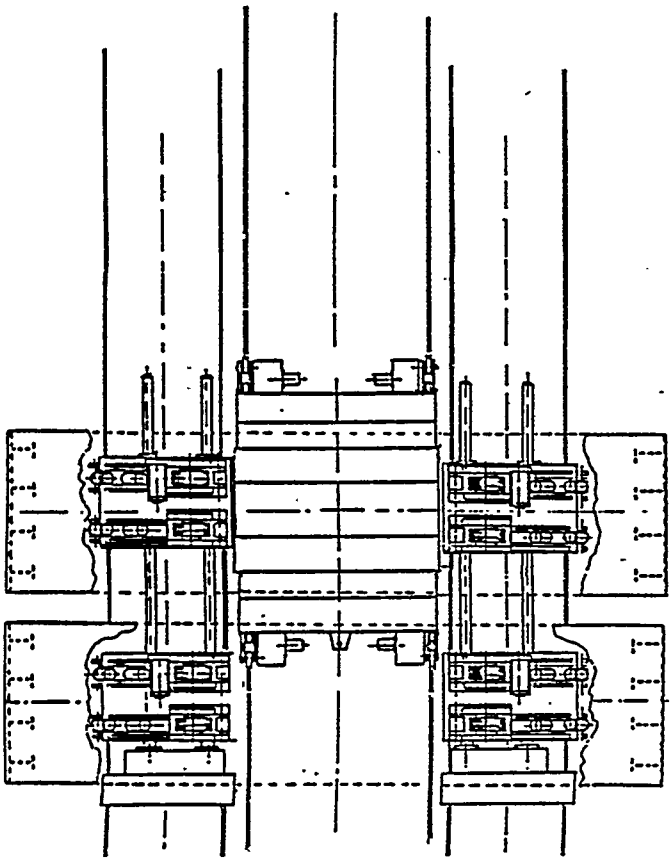
OPERATION 9

CRANE-LOAD TRANSPORT CARRIAGE WITH SHELL2 ONTO CHOCKS ON LOADING PLATFORM SET TO TURNING HEIGHT.

OPERATION SEQUENCE



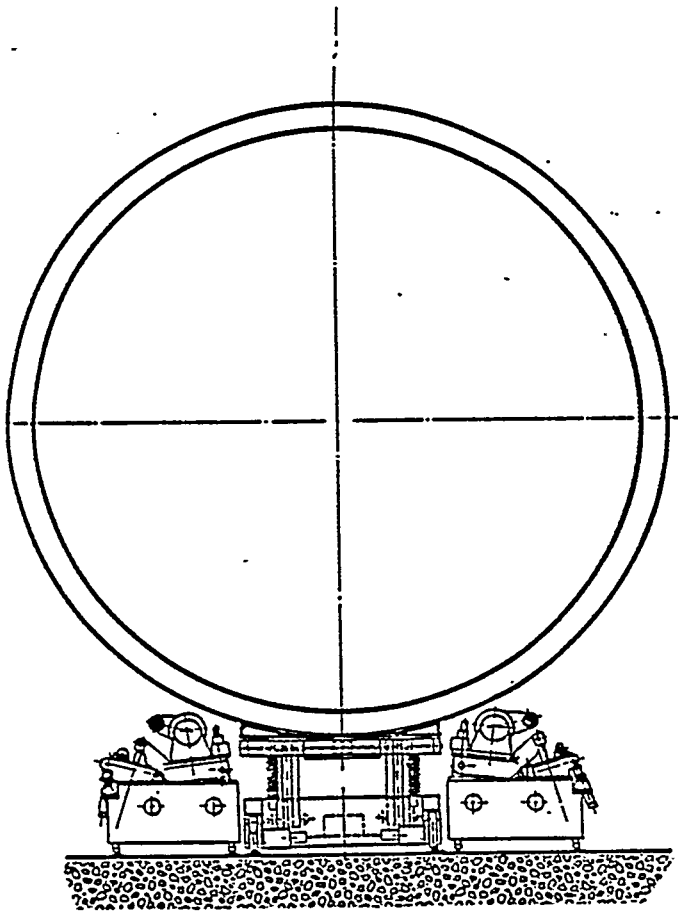


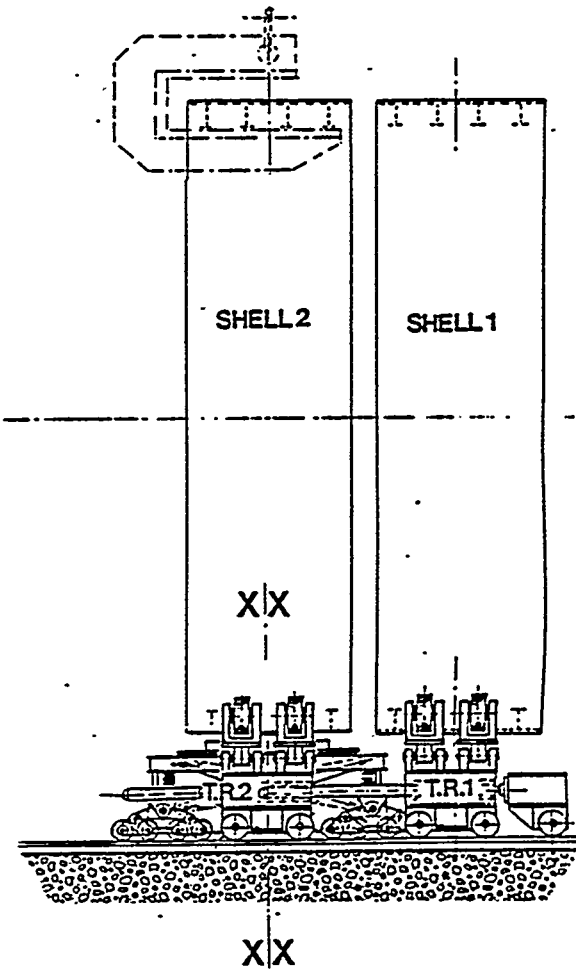


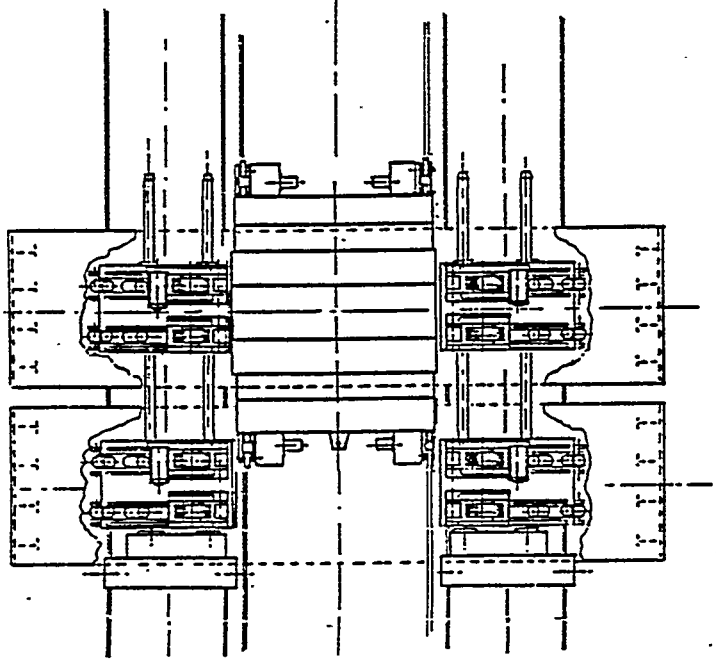
OPERATION 10

TRANSPORT SHELL2 BY TRANSPORT CARRIAGE TO PASS TURNING ROLLS [TR2] INTO TRANSFER LOCATION, THUS ALLOWING OPERATION '11'.

OPERATION SEQUENCE





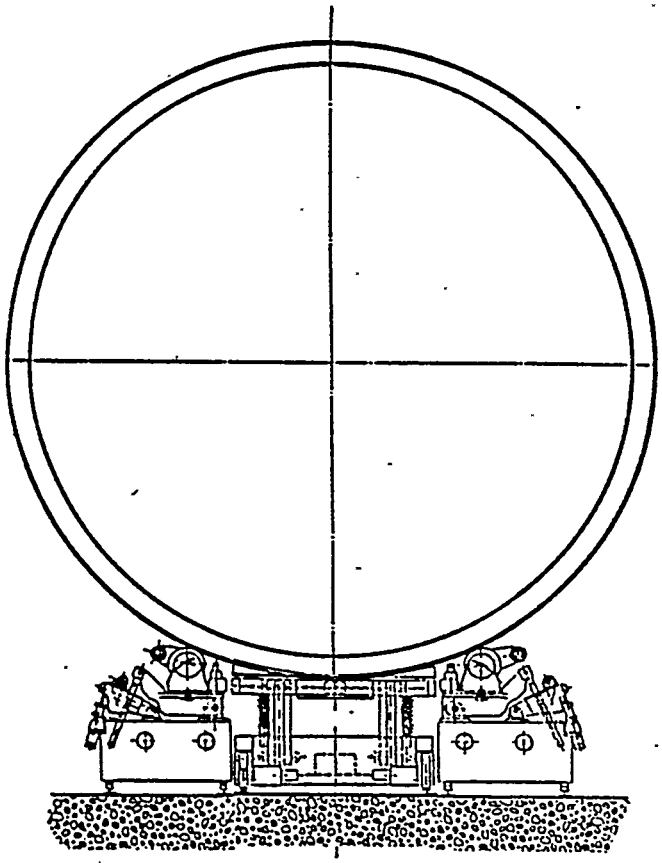


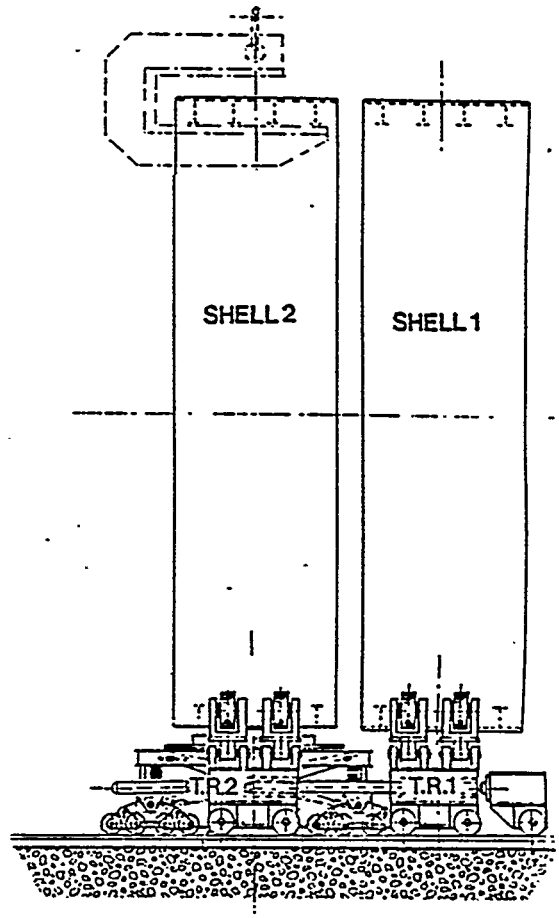
OPERATION 11

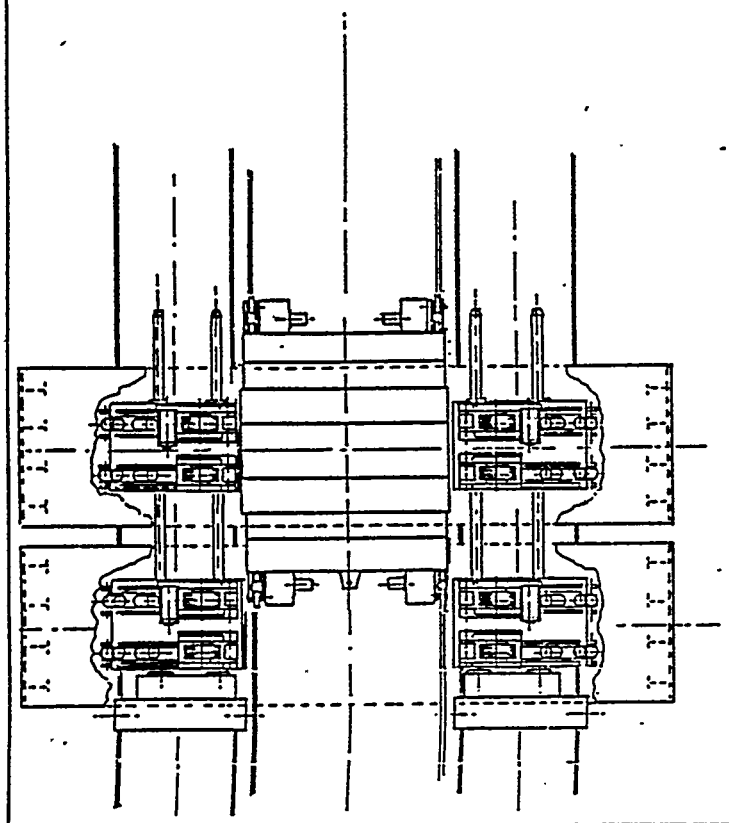
DRIVE SENSOR CONTROLLED TURNING ROLLS [TR2] INTO FINAL SHELL TRANSFER LOCATION. TURNING ROLLS WILL AUTOMATICALLY STOP AT REQUIRED POINT.

XX SHOWS THE PRECISION OF SENSOR CONTROLLED SHELL TRANSFER FROM TRANSPORT CARRIAGE ONTO TURNING ROLLS.

OPERATION SEQUENCE



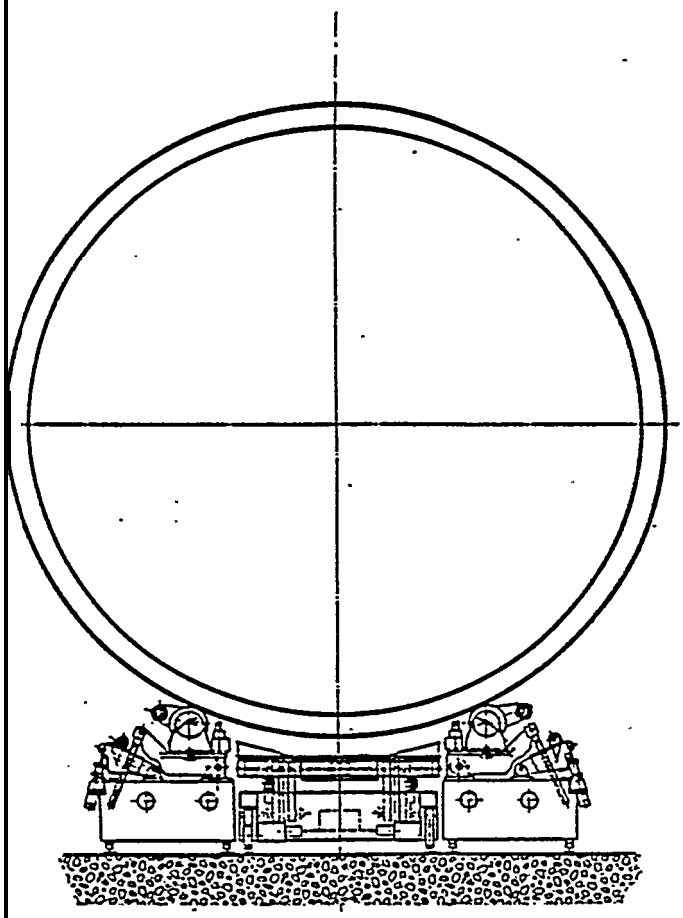


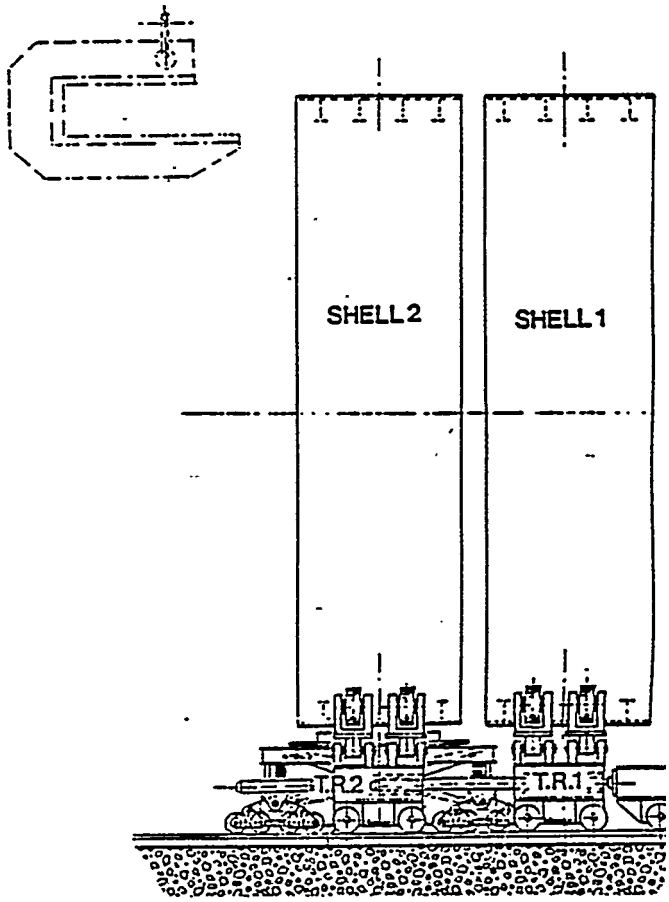


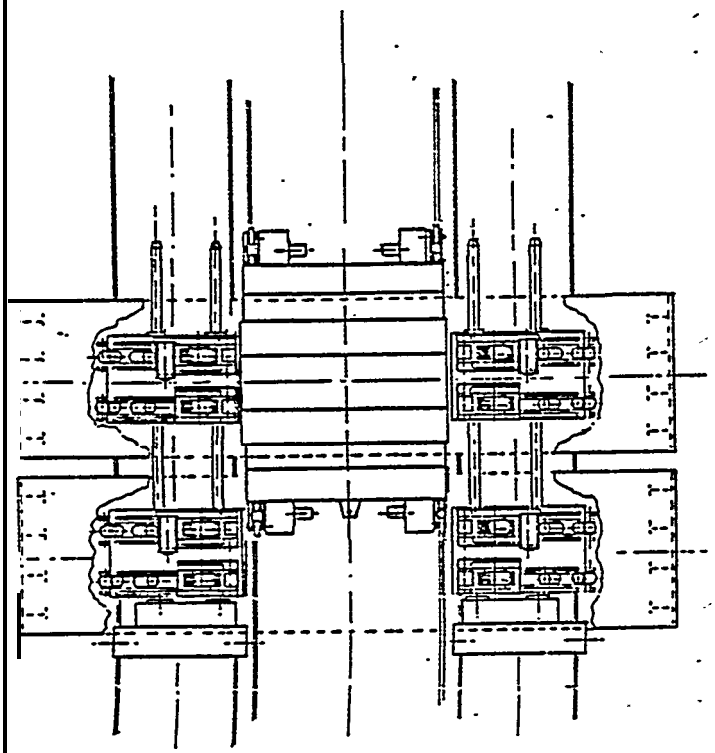
OPERATION 12

- LIFT TURNING ROLLS [TR2] TO TOUCH CONTACT WITH SHELL. AUTOMATIC CUT-OUT IS PROVIDED.

OPERATION SEQUENCE







OPERATION 13

TRANSFER SHELL2 FROM TRANSPORT CARRIAGE ONTO TURNING ROLLS [TR2] ALREADY IN TOUCH CONTACT.

[LOAD TRANSFER ONLY WITHOUT SHELL MOVEMENT].

OPERATION 14

CONTINUE LOWERING TRANSPORT CARRIAGE-LOADING PLATFORM TO CLEARANCE HEIGHT AND DRIVE TRANSPORT CARRIAGE OUT OF TRANSFER AREA.

OPERATION 15

REMOVE CRANE-CRAB.

OPERATION SEQUENCE

OPERATION 16

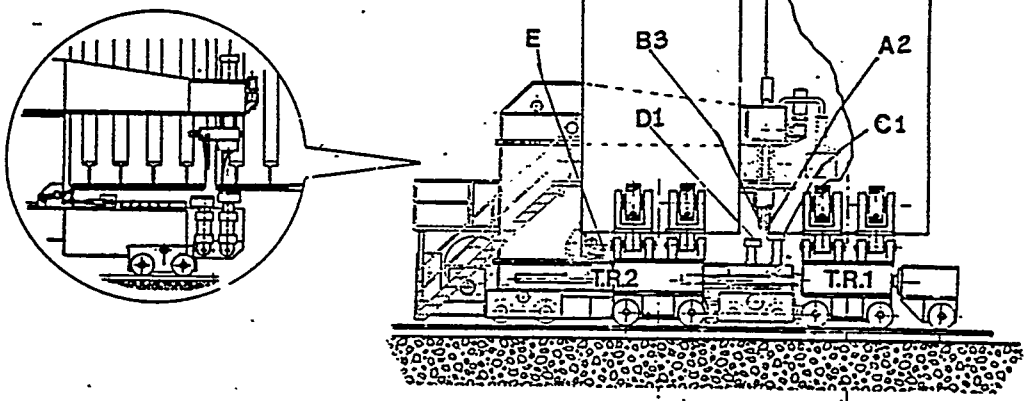
SET TURNING ROLL BOGIES AS FOLLOWS:

a] BOGIES CARRYING SHELL1 WITH DRIVING GEARS ENGAGED AND RAIL CLAMPS ON.

b] BOGIES CARRYING SHELL2 WITH DRIVING GEARS DE-CLUTCHED AND RAIL CLAMPS RELEASED.

OPERATION 17

CLAMP TRAILING EDGE OF SHELL1 BETWEEN EXTERNAL PRESS [C1] AND INTERNAL BACKSTOP [A2].



OPERATION 18

SHUNT SHELL2 ON TURNING ROLL [TR2] BY HORIZONTAL PRESS [E] TO ACHIEVE THE BUTT TO BUTT ASSEMBLY REQUIRED.

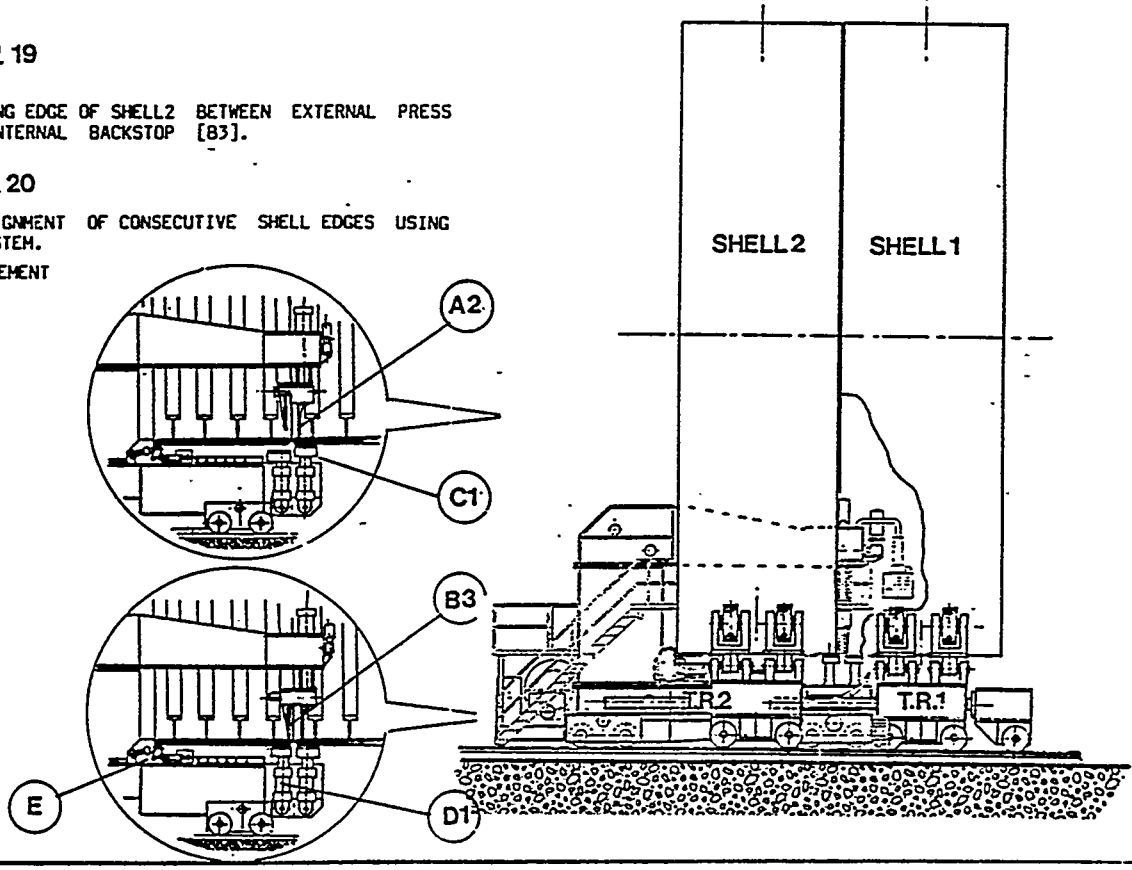
OPERATION 19

CLAMP LEADING EDGE OF SHELL2 BETWEEN EXTERNAL PRESS [D1] AND INTERNAL BACKSTOP [B3].

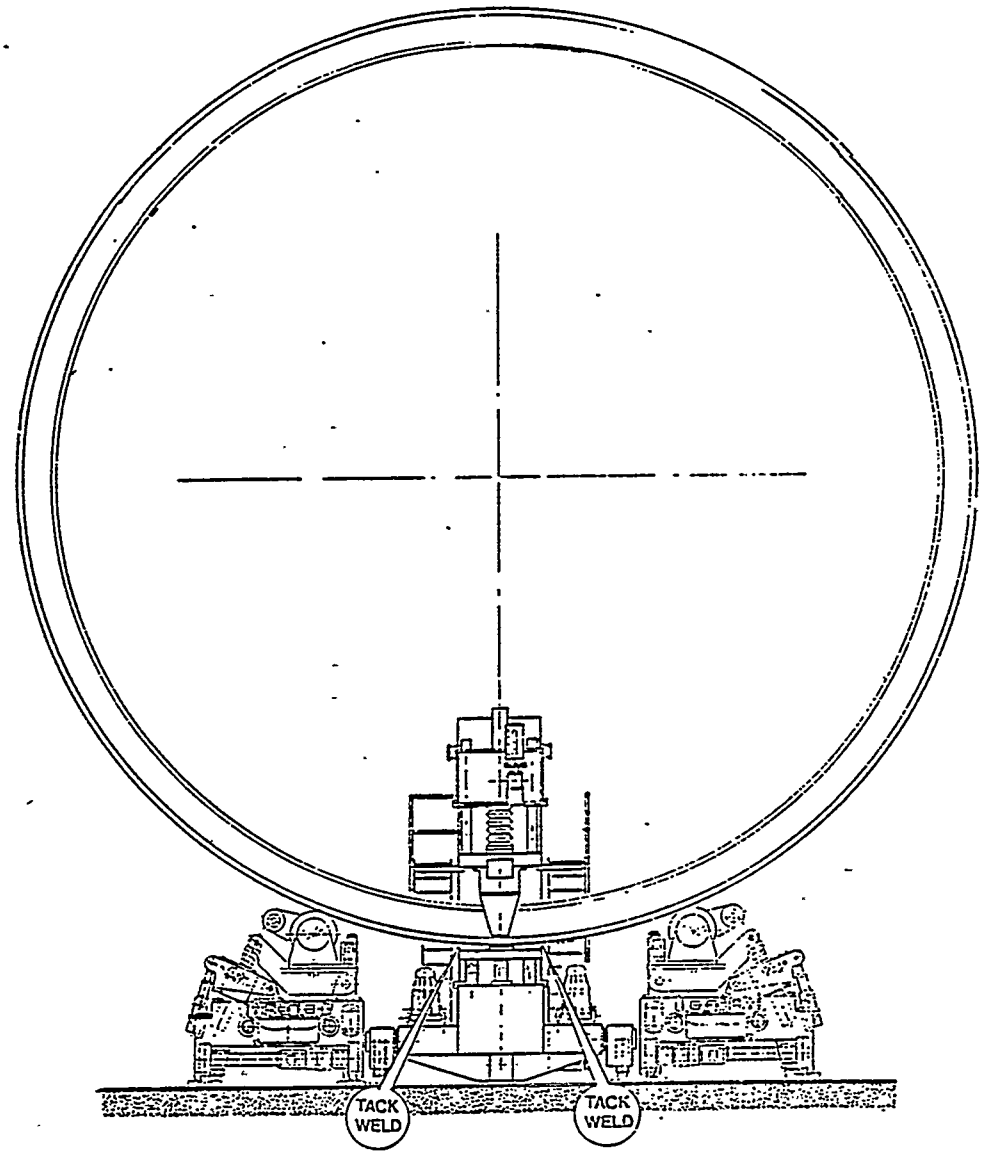
OPERATION 20

PERFORM ALIGNMENT OF CONSECUTIVE SHELL EDGES USING CLAMPING SYSTEM.

REQUIREMENT



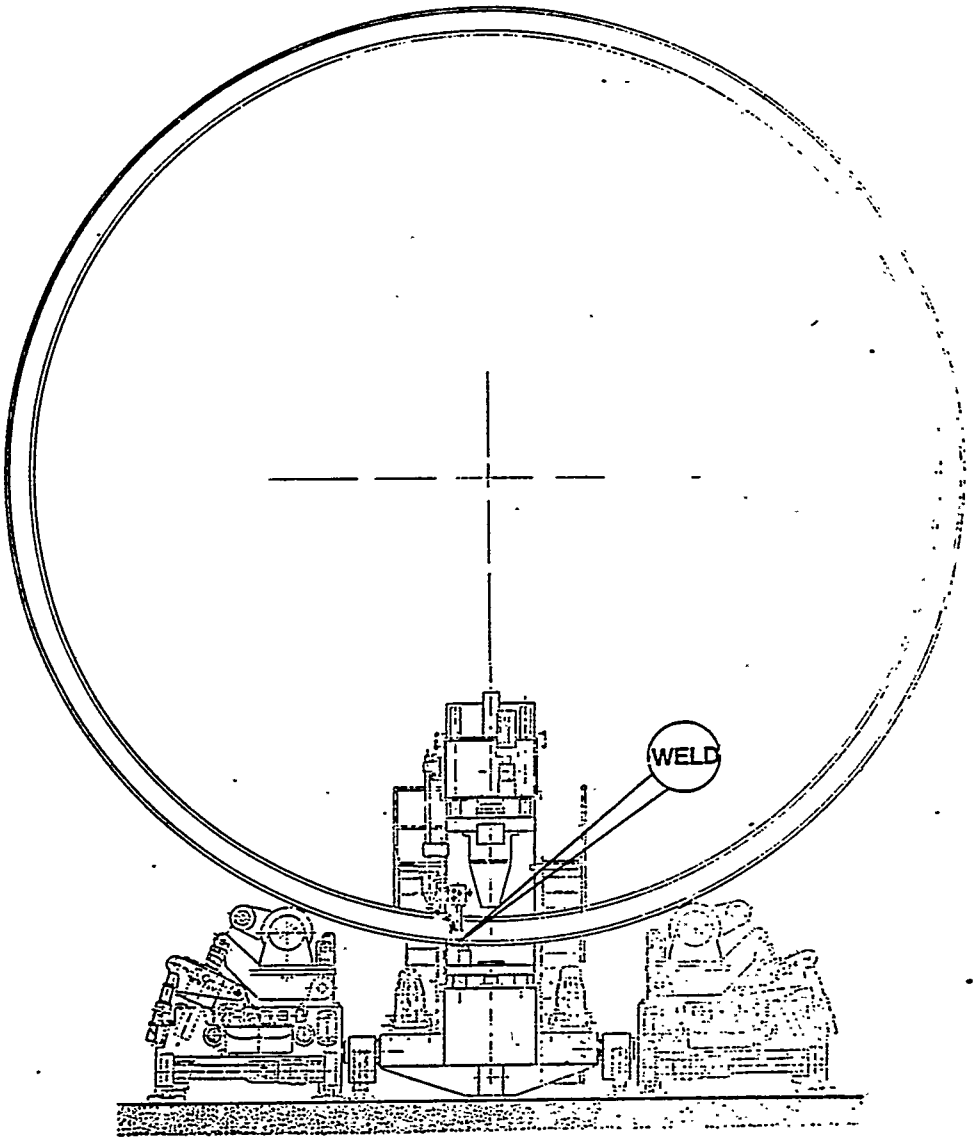
OPERATION SEQUENCE



OPERATION 21

EXTERNAL TACK WELD ALONG CIRCUMFERENCE MATCHED AND CLAMPED. ON COMPLETION OF TACKING, RELEASE PRESSES, RE - POSITION TANK ON TURNING ROLLS, REPEAT OPERATIONS 18 - 20, AND EXTERNAL TACK WELD AS BEFORE. CONTINUE IN THE SAME MANNER UNTIL TACKING OPERATION COMPLETED THROUGHOUT THE WHOLE CIRCUMFERENCE RELEASE PRESSES FOR INTERNAL CIRC-WELDING.

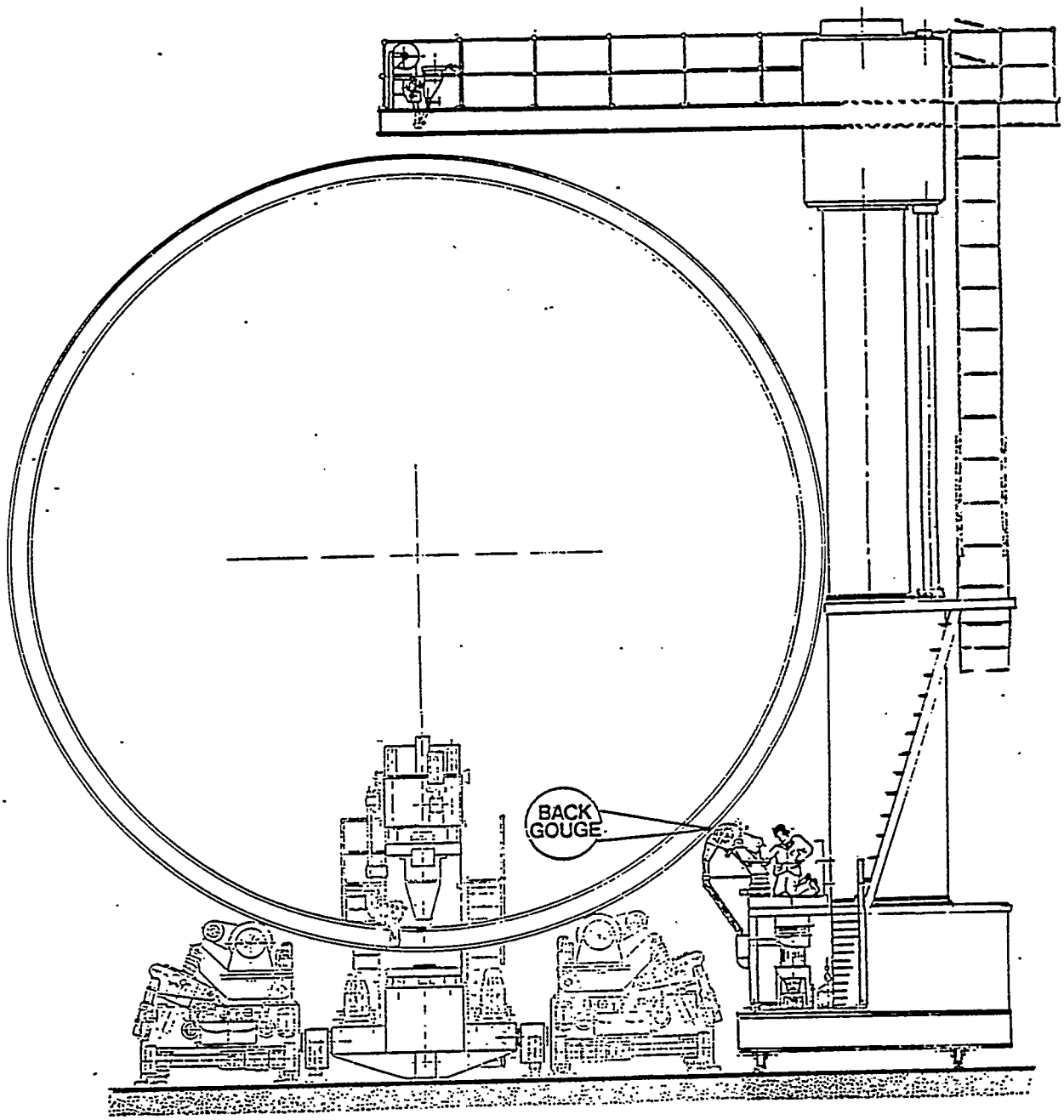
OPERATION SEQUENCE



OPERATION 22

RAISE CONTINUOUS EXTERNAL FLUX BACKING UNIT FROM ITS PARKED POSITION TO CONTACT UNDERSIDE OF SHELL. POSITION WELDING EQUIPMENT AND MAKE FOUR INTERNAL PASSES OF WELD THROUGHOUT WHOLE CIRCUMFERENCE OF SHELL.

OPERATION SEQUENCE

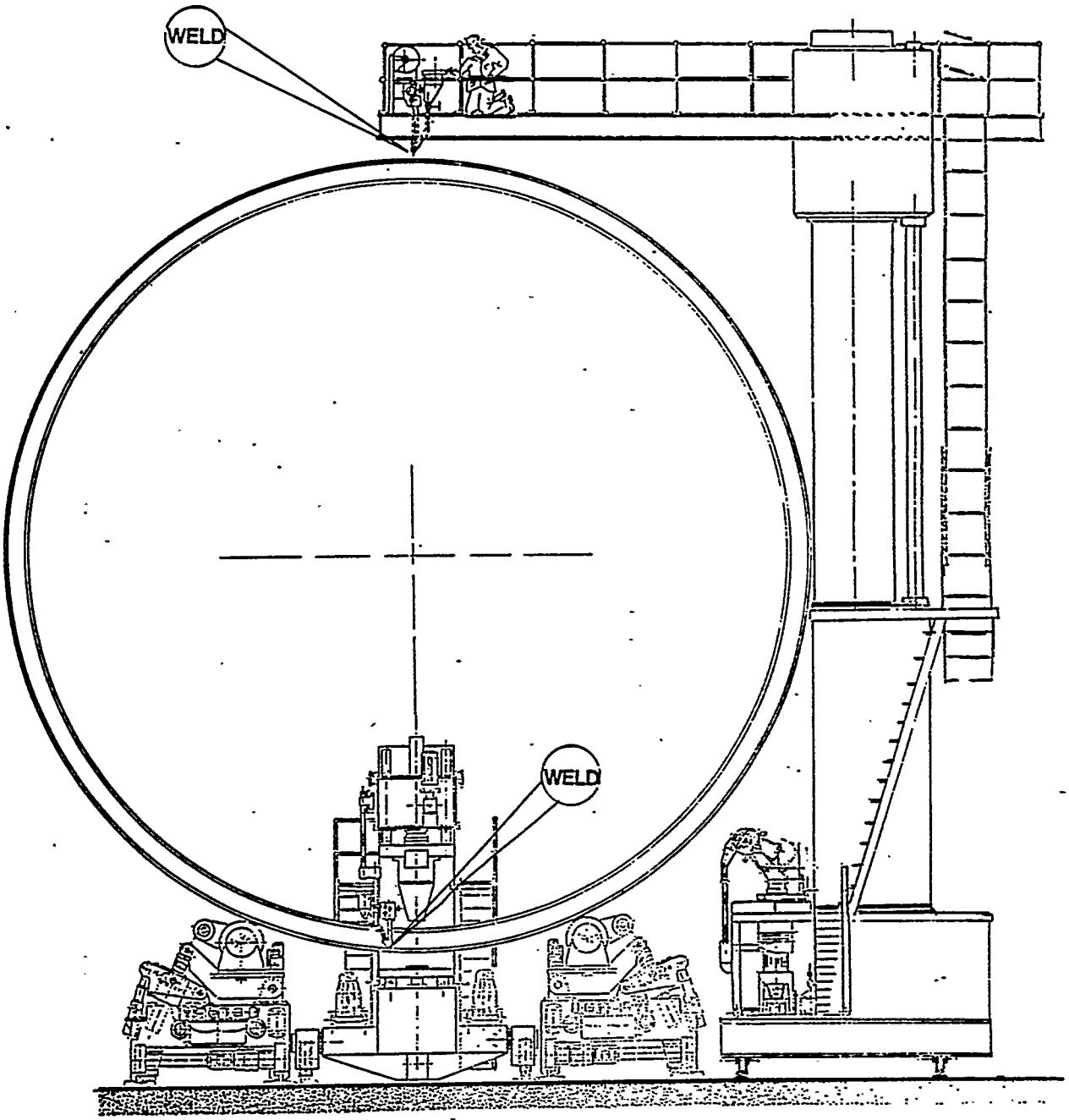


OPERATION 23

RETRACT FLUX BACKING UNIT AND POSITION THE BACK-GOUGING EQUIPMENT WHICH IS MOUNTED ON THE TRAVELLING BASE OF THE EXTERNAL WELDING BOOM TO ALIGN WITH THE WELD SEAM.

BACK GOUGE TACK WELDS AND ROOT PENITRATION TO CLEAN UNIFORM CONTOUR USING TURNING ROLLS FOR ROTATION OF SHELL.

OPERATION SEQUENCE

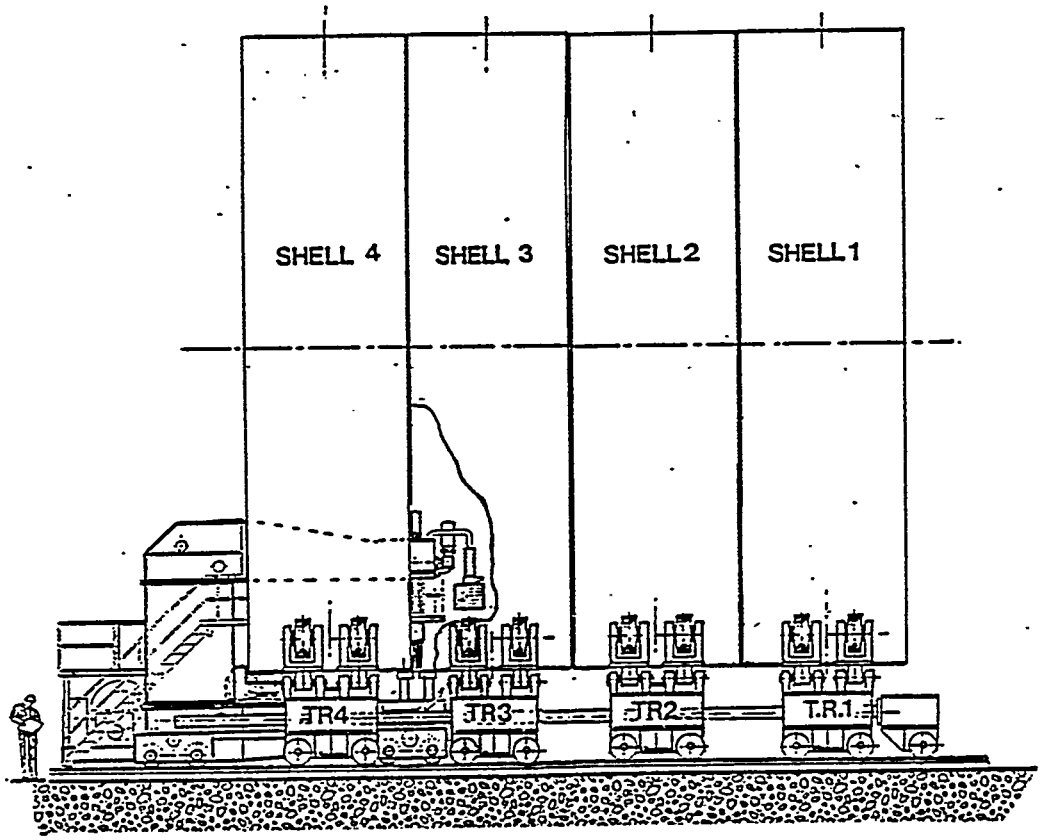


OPERATION 24

COMPLETE THE WELD BY MULTI-PASS RUNS EXTERNALLY USING THE WELDING BOOM.

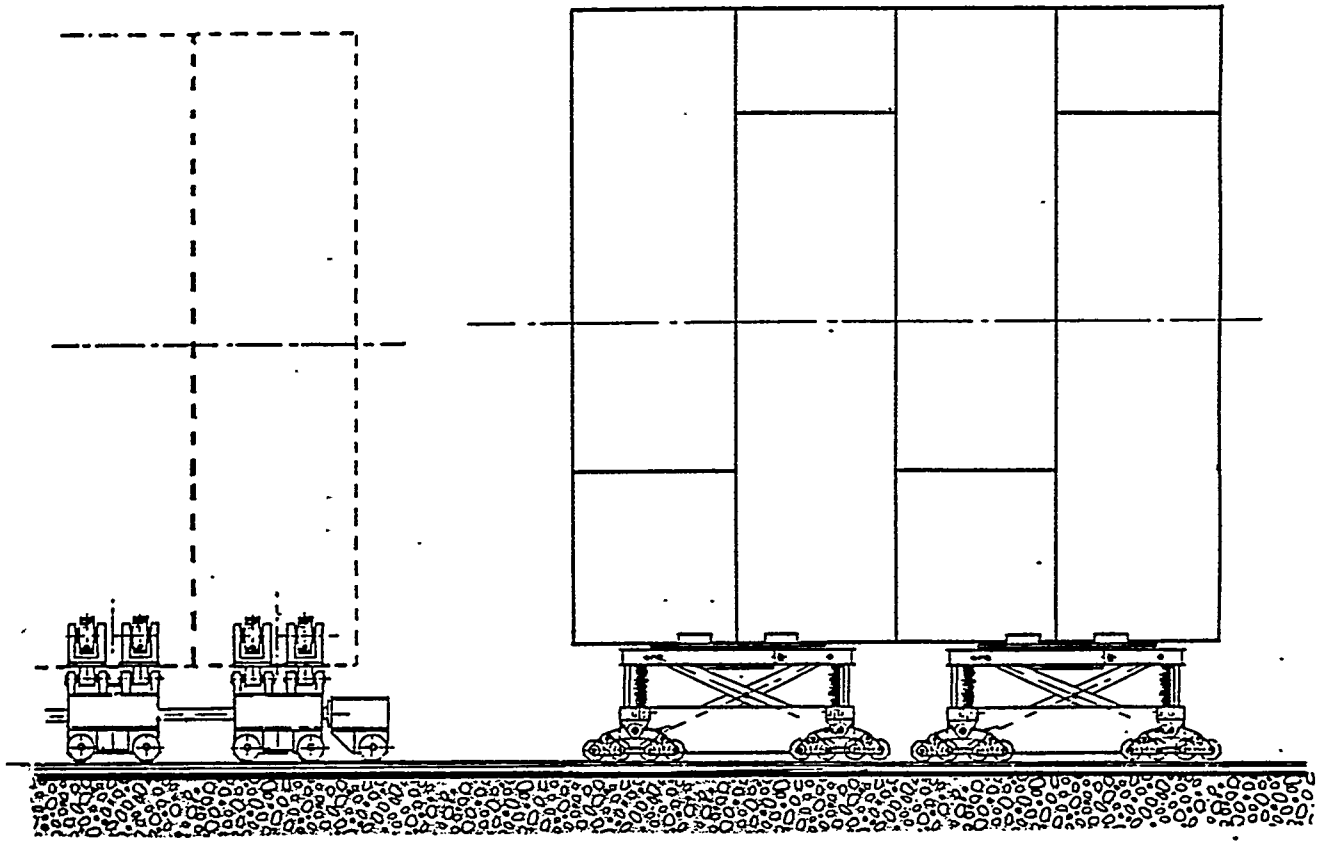
AT THE SAME TIME COMPLETE THE INTERNAL WELD SEAM WITH THE APPROPRIATE NUMBER OF RUNS OF WELD.

OPERATION SEQUENCE



COMPLETE ASSEMBLY AS SHOWN ABOVE, ACHIEVED BY
REPEATING OPERATIONS 1 TO 24 PREVIOUSLY DESCRIBED

OPERATION SEQUENCE



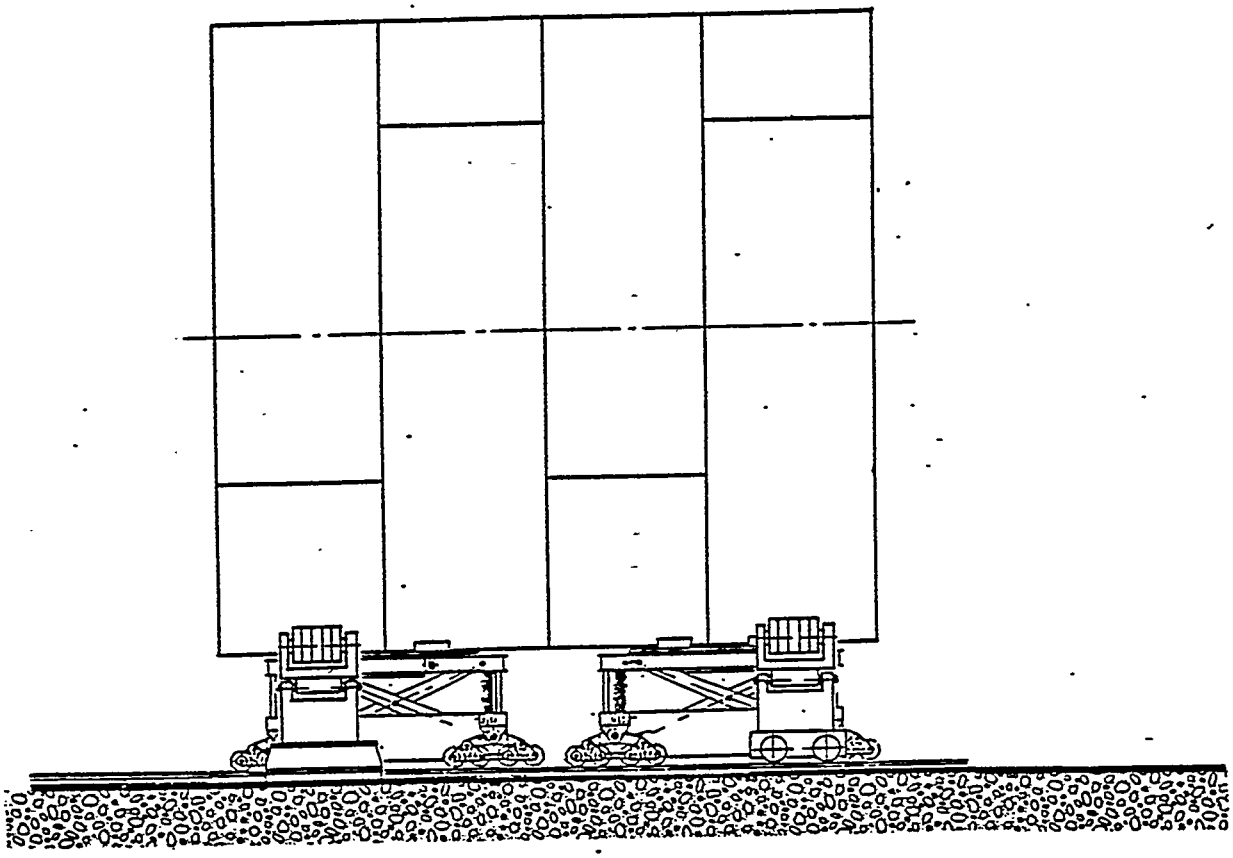
OPERATION 25

DRIVE TRANSPORT CARRIAGE[S] INTO POSITION BENEATH ASSEMBLED SHELLS AT CLEARANCE HEIGHT.

OPERATION 26

RAISE TRANSPORT CARRIAGE PLATFORM[S] TO TOUCH CONTROL HEIGHT AND TRANSFER LOAD FROM TURNING ROLLS TO TRANSPORT CARRIAGE[S].

OPERATION 27



OPERATION 28

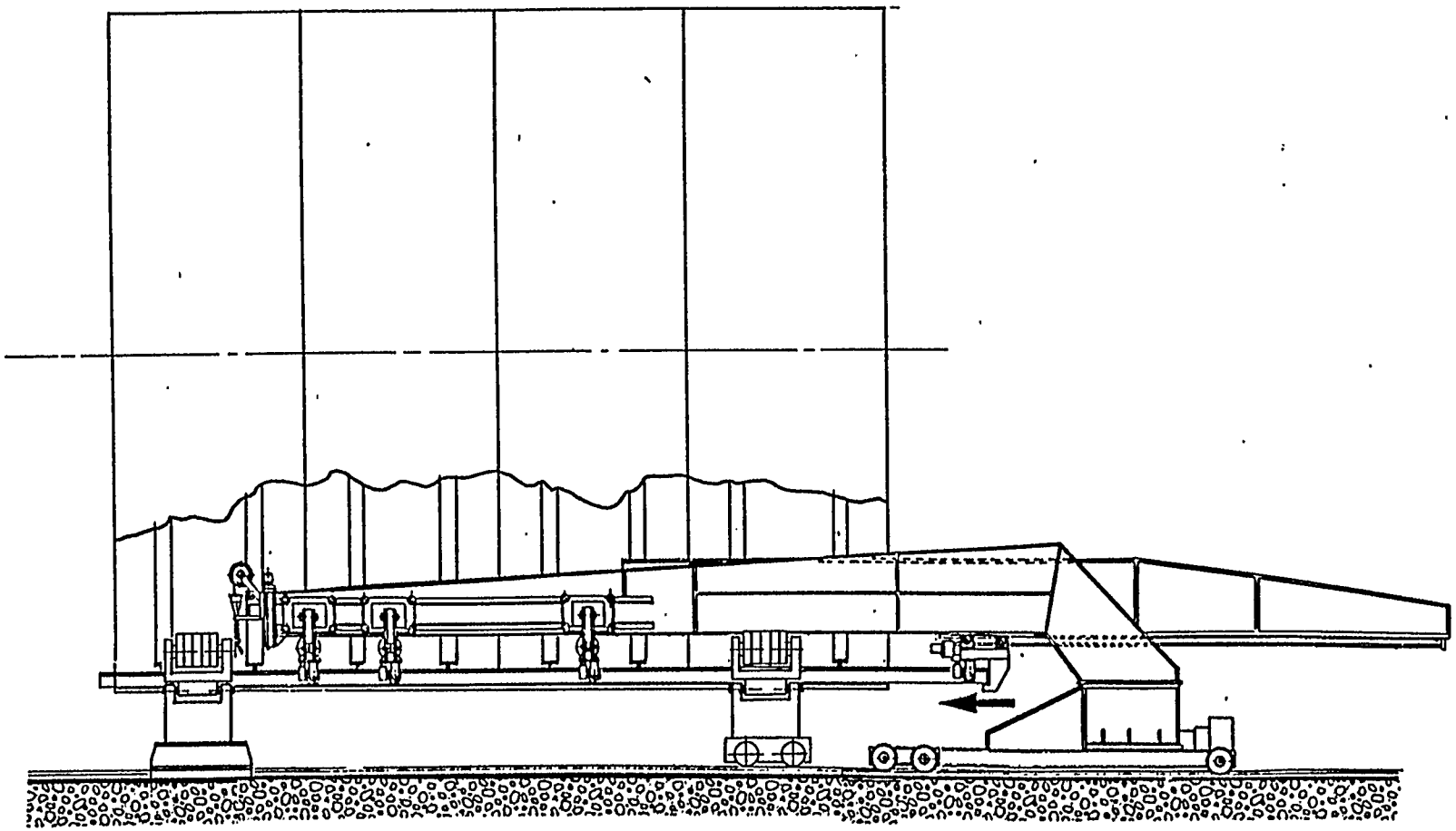
RAISE SECONDARY TURNING ROLLS TO WORKING HEIGHT WITH TOUCH CONTROL ON SHELL.

OPERATION 29

TRANSFER LOAD **FROM TRANSPORT CARRIAGE[S] TO TURNING ROLLS.**

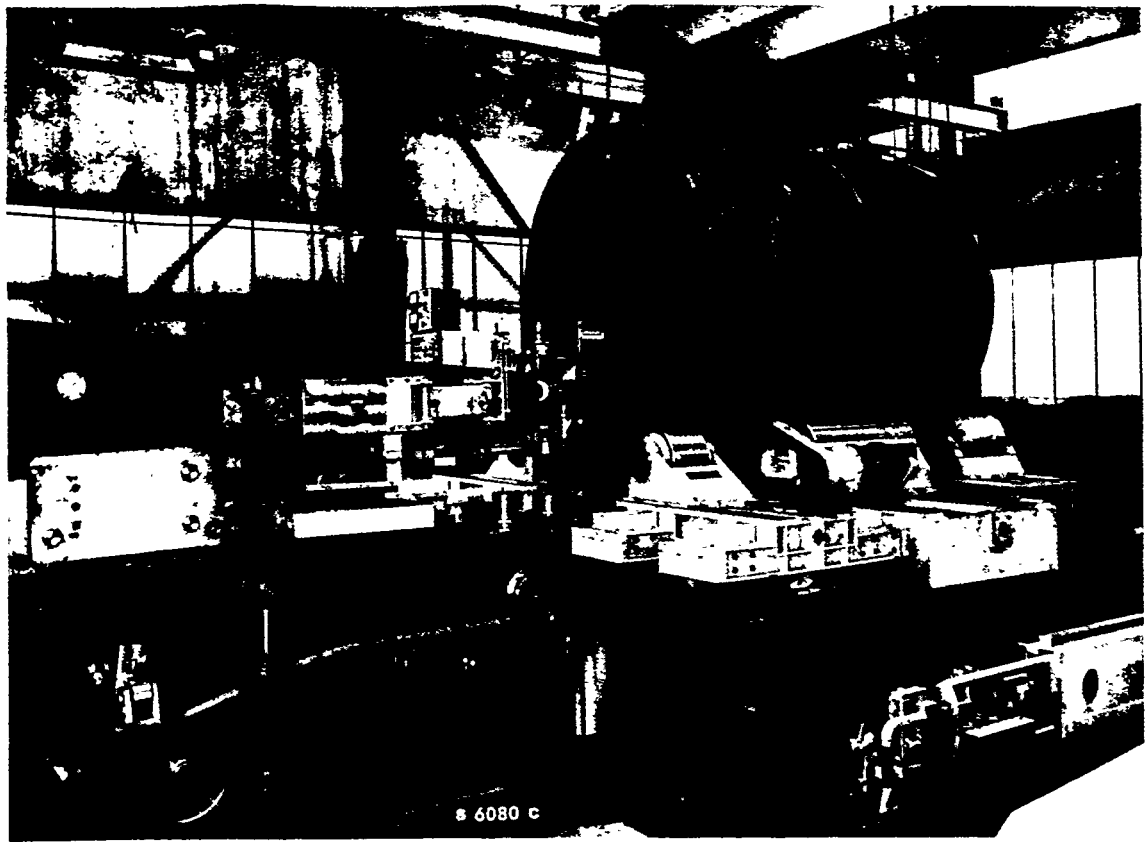
OPERATION 30

LOWER TRANSPORT CARRIAGE[S] TO CLEARANCE HEIGHT AND WITHDRAW FROM WORKING AREA.

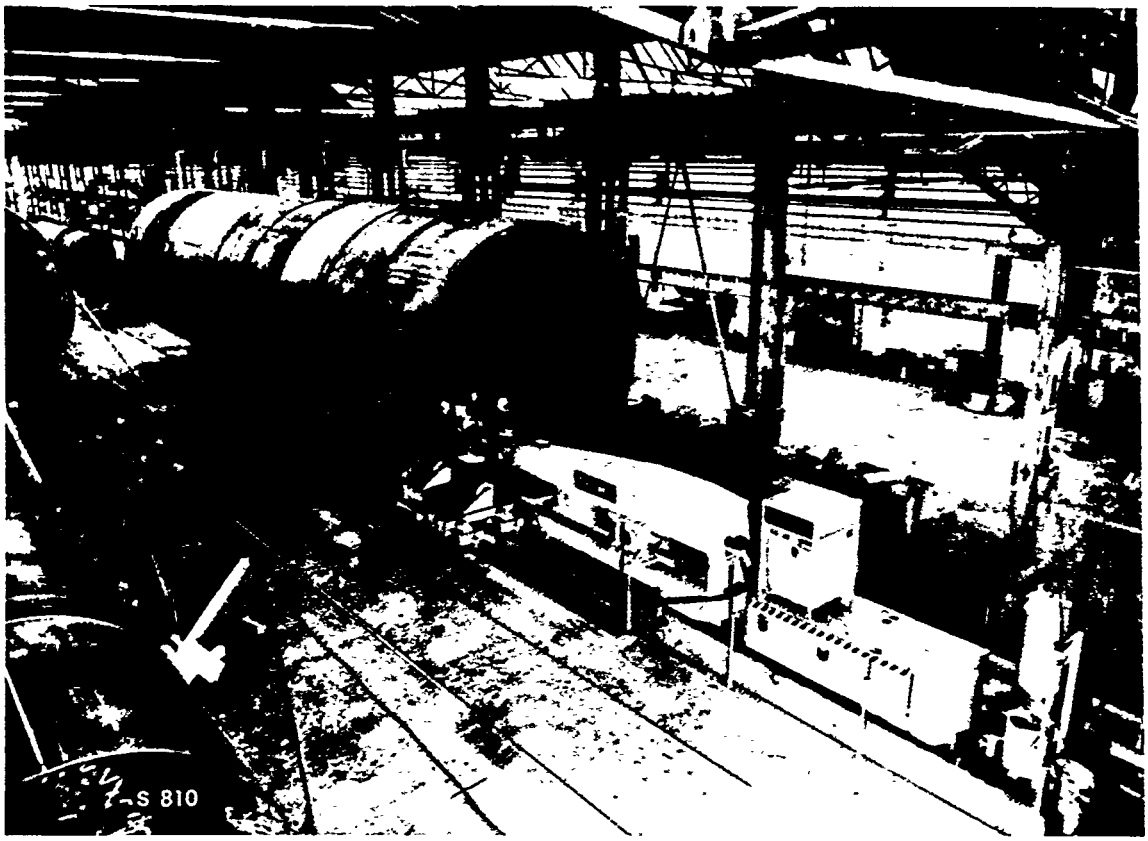


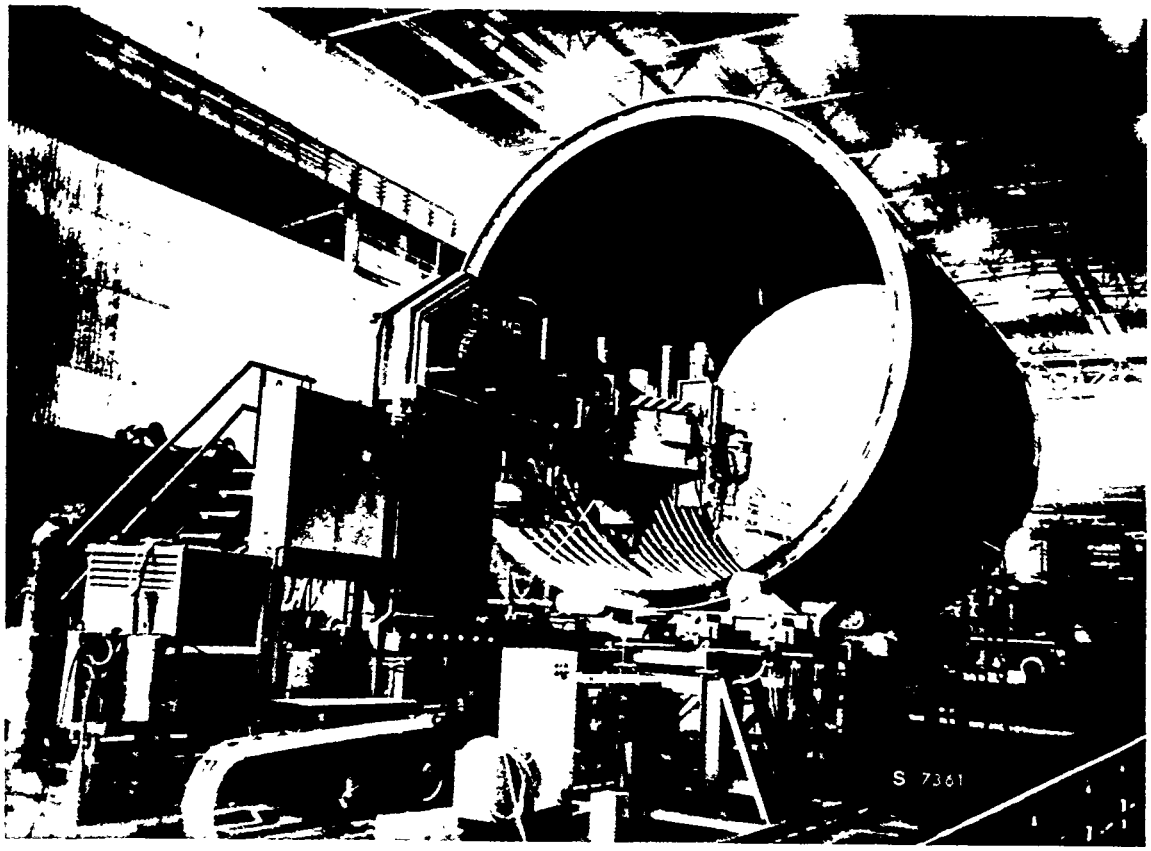
OPERATION 31

DRIVE AXIAL REINFORCEMENT PROFILE FEEDER INTO POSITION.
FEED AND WELD PROFILES TO SHELL AND TO CIRCUMFERENTIAL TEE BARS.
REPOSITION SHELL BY ROTATION OF SECONDARY TURNING ROLLS TO PERMIT SUCCESSIVE PROFILES TO BE FED.



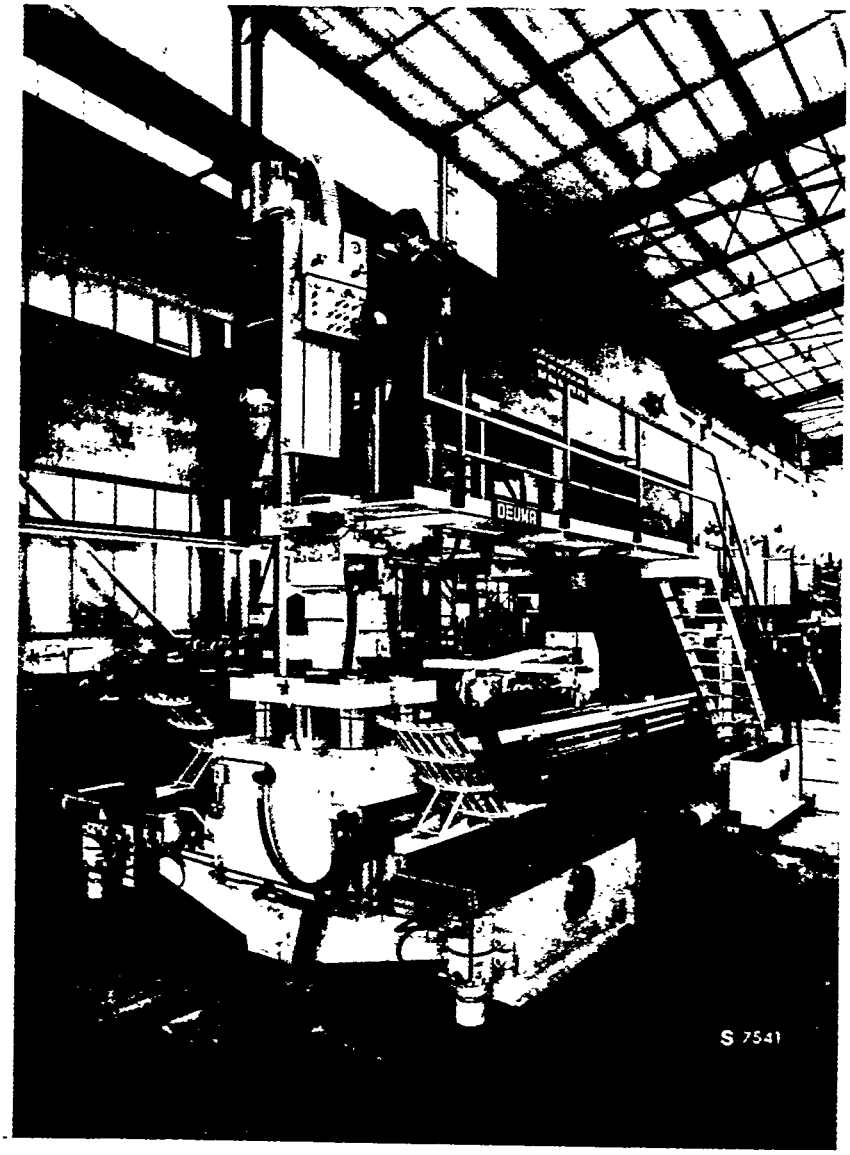
THE CROCODILE / TYPE : 814 CYLINDRICAL VESSEL ASSEMBLING **LINE**





SHIPYARD CROCODILE / TYPE : 814 NS

[LARGE DIAMETER RE-INFORCED SHELL ASSEMBLY LINE]



SHIPYARD CROCODILE / TYPE : 814 NS

[EXTRA LARGE DIAMETER RE-INFORCED SHELL ASSEMBLY LINE]

ADDENDUM ONE - DEALING WITH THE FITTING AND WELDING OF CYLINDERS IN THE LOWER RANGE BETWEEN 2 AND 14 FEET IN DIAMETER UP TO 4.5 TONS PER LINEAR FOOT AND LENGTH TO REQUIREMENT.

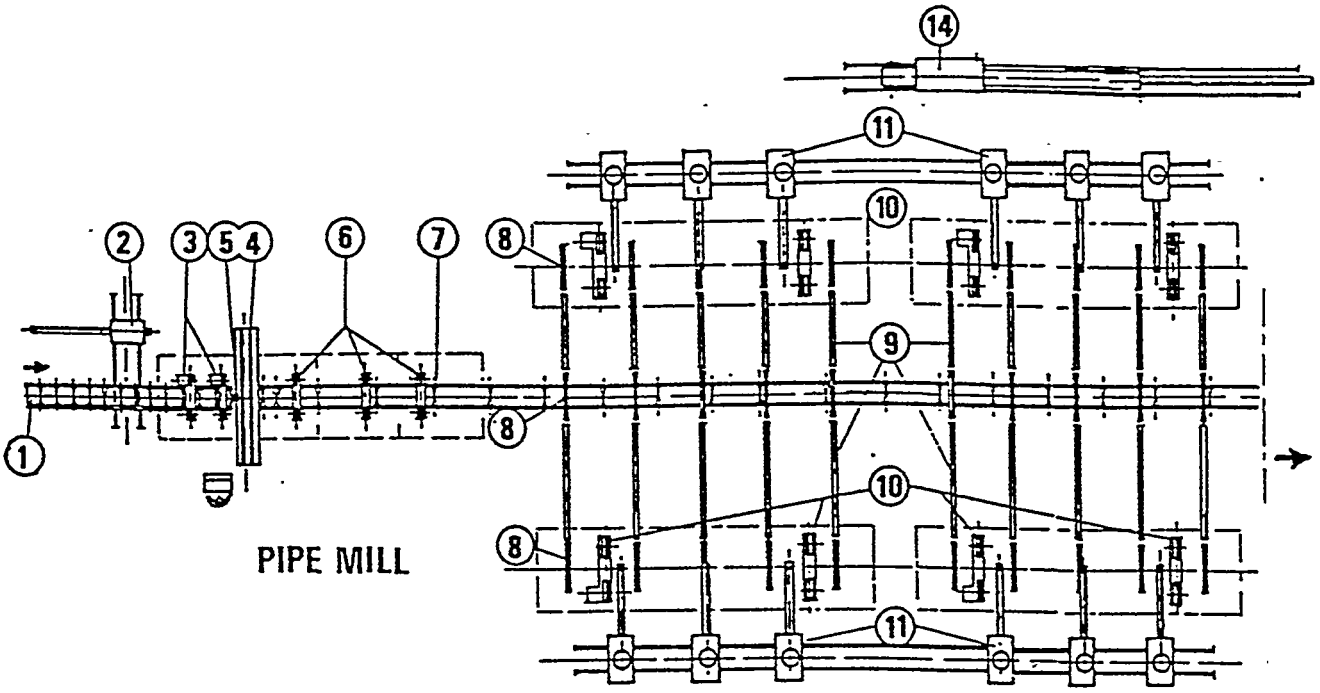
ONE MOTORIZED HEAVY DUTY TUBULAR PRODUCTION LINE WITH INTEGRATED TRANSPORT SYSTEM BUILT TO FOLLOWING SPECIFICATION [PRINT NO. MPS :2]

DIAMETERS	3 FT. TO 12 FT.
PLATE THICKNESS	1.1/2 TO 6 INCHES
WEIGHT OF CAN [MAX.]	4.11 I LONG TONS PER LINEAR FT.
LENGTH OF CAN INTO PIPE MILL	5 FT. To 12 FT.
LENGTH OF PIPE OUT OF PIPE MILL	*40FT* To 48 FT.
LENGTH OF PIPE INTO PIPE RACK	40 FT. TO 48 FT.
LENGTH OF PIPE OUT OF PIPE RACK	160 FT. TO 192 FT.

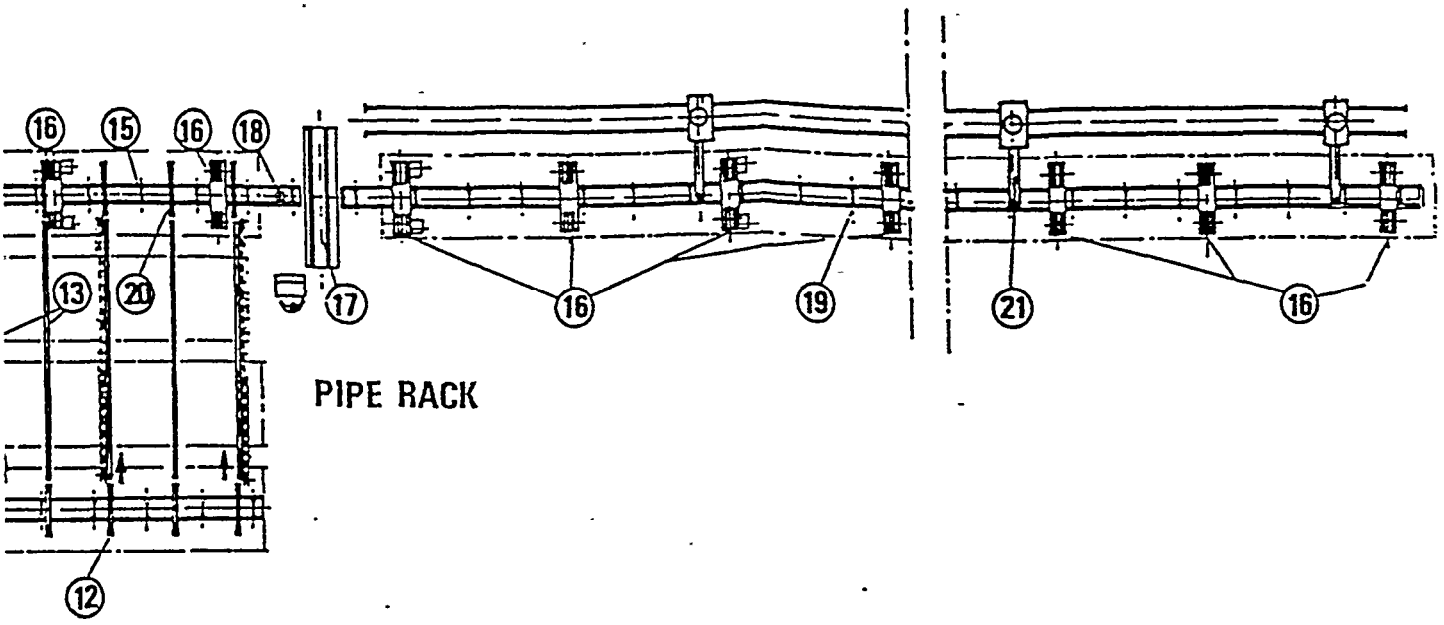
THE PRODUCTION LINE IS MADE UP OF TWO STATIONS , A & B AS SET OUT BELOW

STATION *A :* PIPE MILL WITH ONE INTERNAL AND FOUR EXTERNAL WELDING STATIONS, COMPLETE WITH ALL REQUIRED TRANSPORT/TRANSFER AND ROUNDING MECHANISM. CAPACITY 200 LONG TONS PER PIPE LENGTH OF 48 ET.

STATION B: PIPE RACK WITH ONE INTERNAL AND THREE EXTERNAL WELDING POSITIONS, COMPLETE WITH LOADING, TRANSPORTING AND ROUNDING MECHANISM. CAPACITY UP TO 800 LONG TONS PER PIPE LENGTH *OF 192* FT



1	SPRING LOADED TRANSPORT ROLLERS	12	HY
2	INTERNAL CIRC-WELDING MANIPULATOR	13	MC
3	HYDRO-MECHANICAL TURNING ROLLS	14	IN
4	ROUNDING ALIGNING ASSEMBLING STATION	15	SP
5	EXTERNAL FLUX BACKING SYSTEM	16	TL
6	HYDRO-MECHANICAL TURNING ROLLS	17	RC
7	SPRING LOADED TRANSPORT ROLLERS	18	EXi
8	HYDRO-MECHANICAL LOADERS/UNLOADERS	19	SP
9	BUFFER RAILS	20	H,
10	HYDRO-MECHANICAL TURNING ROLLS	21	EX
11	EXTERNAL CIRC-WELDING STATIONS		



PIPE RACK

-MECHANICAL LOADERS/UNLOADERS
ZED TRANSFER MECHANISM
AL CIRC-WELDING MANIPULATOR
-LOADED TRANSPORT ROLLERS
G ROLL SYSTEM HYDRO-MECHANICAL
NG, ALIGNING ASSEMBLING STATION
IAL FLUX BACKING SYSTEM
LOADED TRANSPORT ROLLERS
-MECHANICAL LOADERS/UNLOADERS
IAL CIRC-WELDING MANIPULATORS

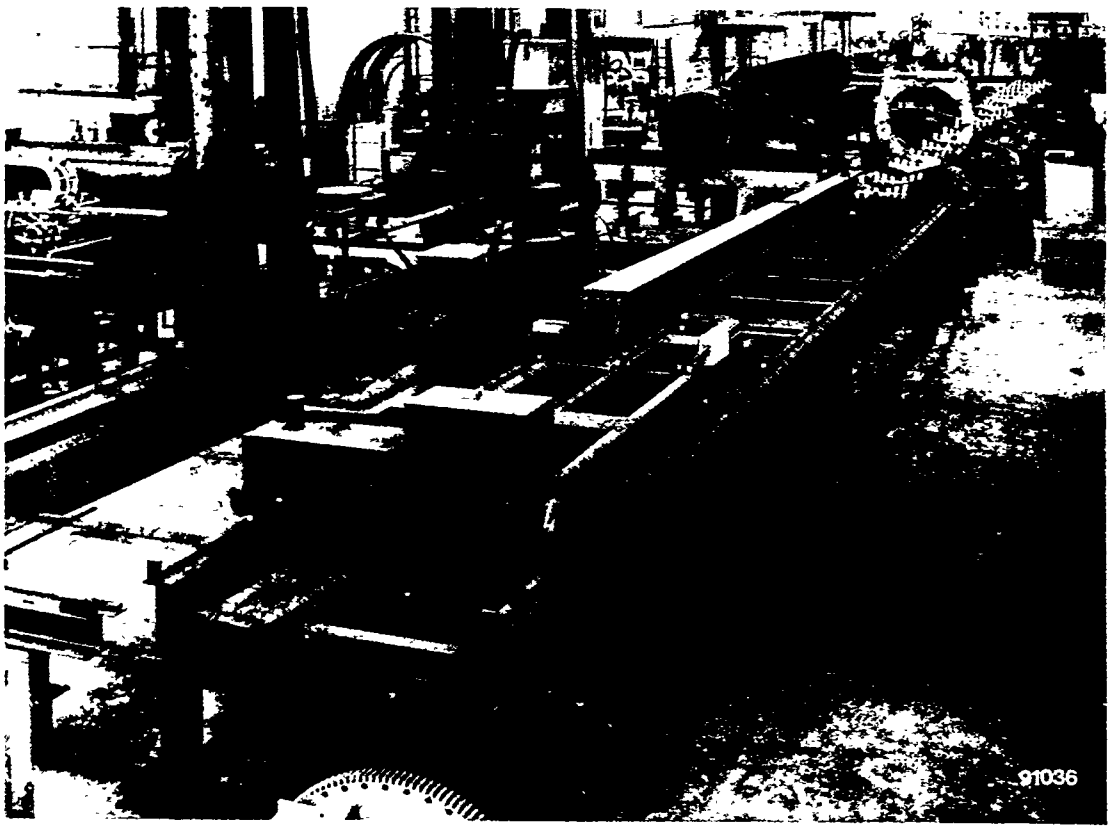
MECHANISED PRODUCTION SYSTEM

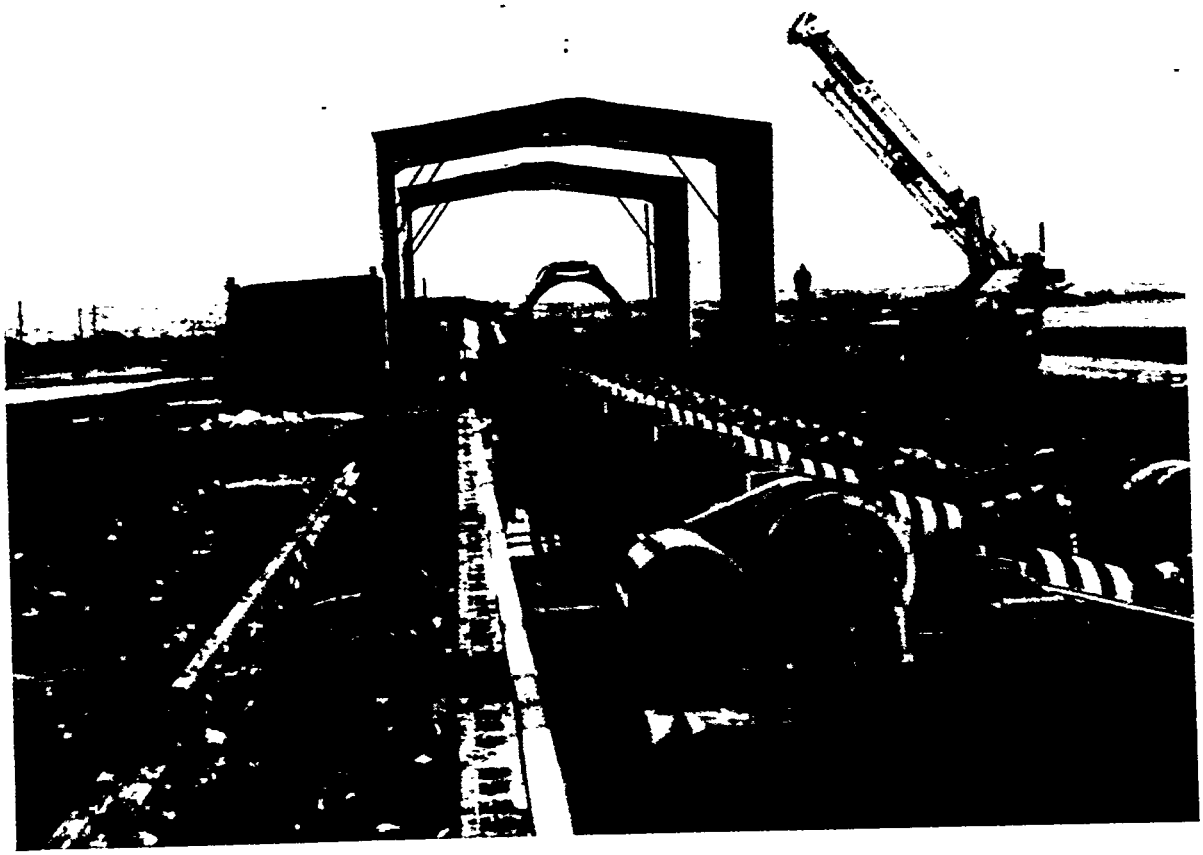
FOR

FITTING AND WELDING

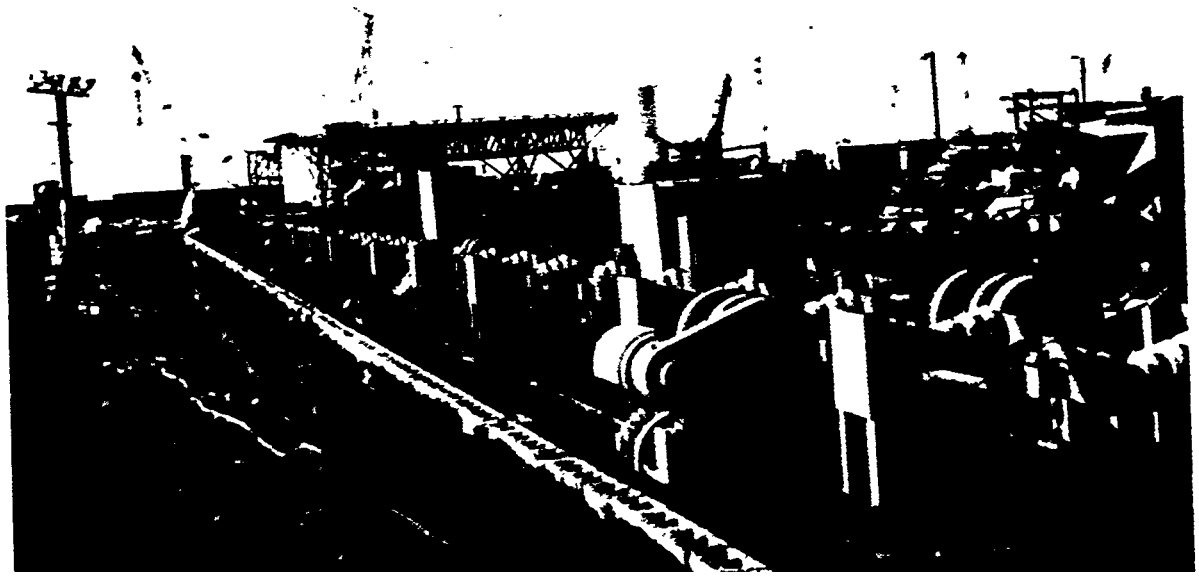
CYLINDERS OF 2 FEET TO 14 FEET DIAMETER

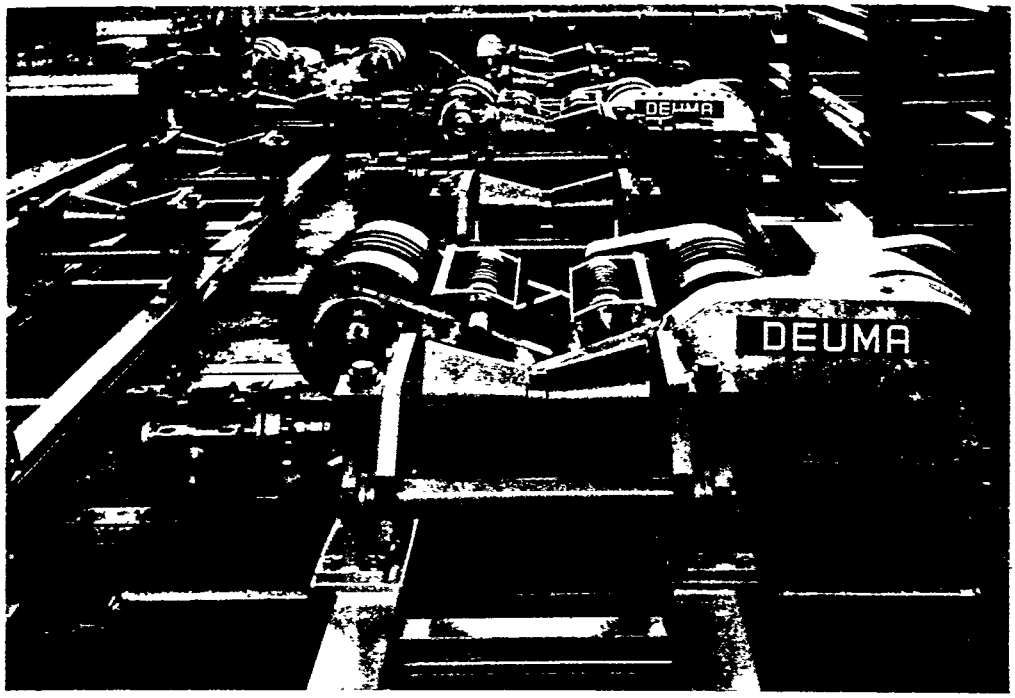
PIPE MILL



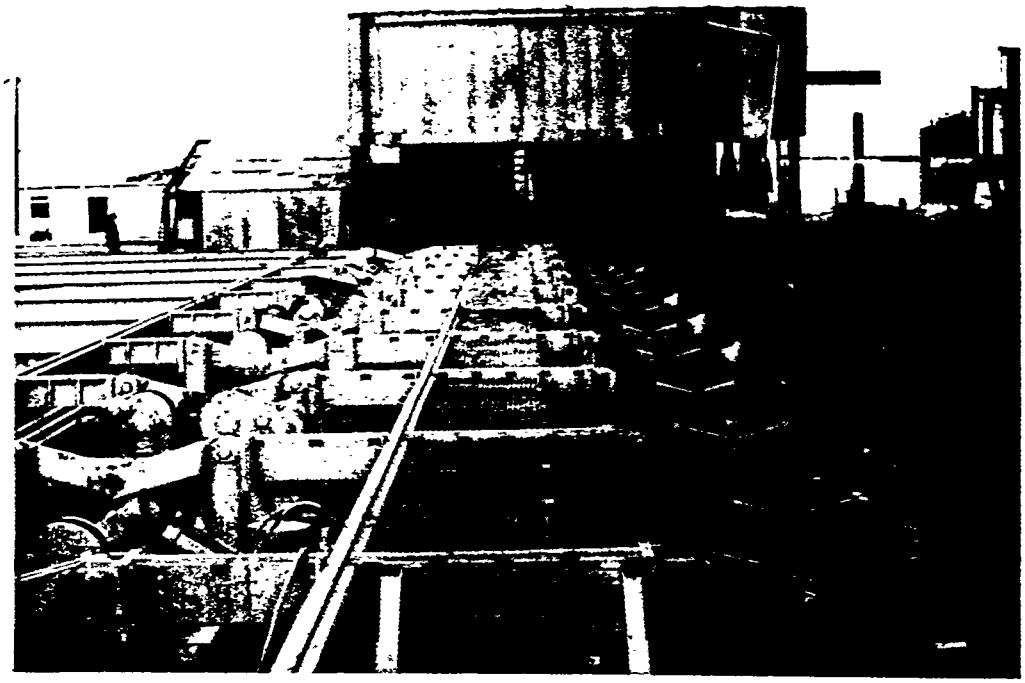


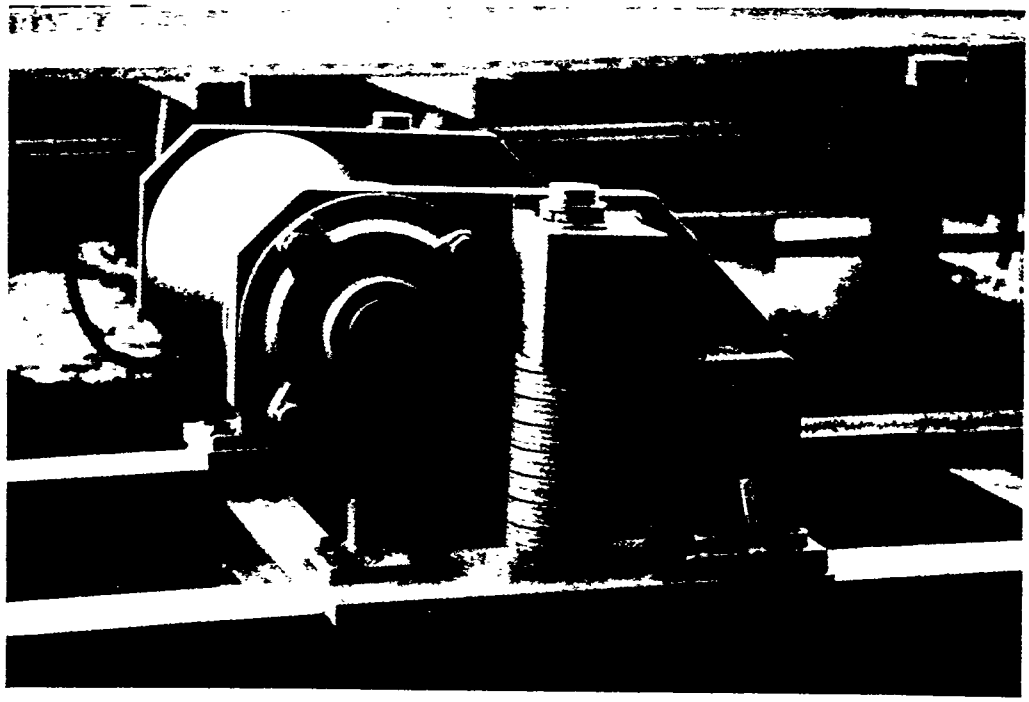
PIPE RACK 320 FT. LONG WITH ALIGNING, ASSEMBLING & ROUNDING/CLAMPING STATION



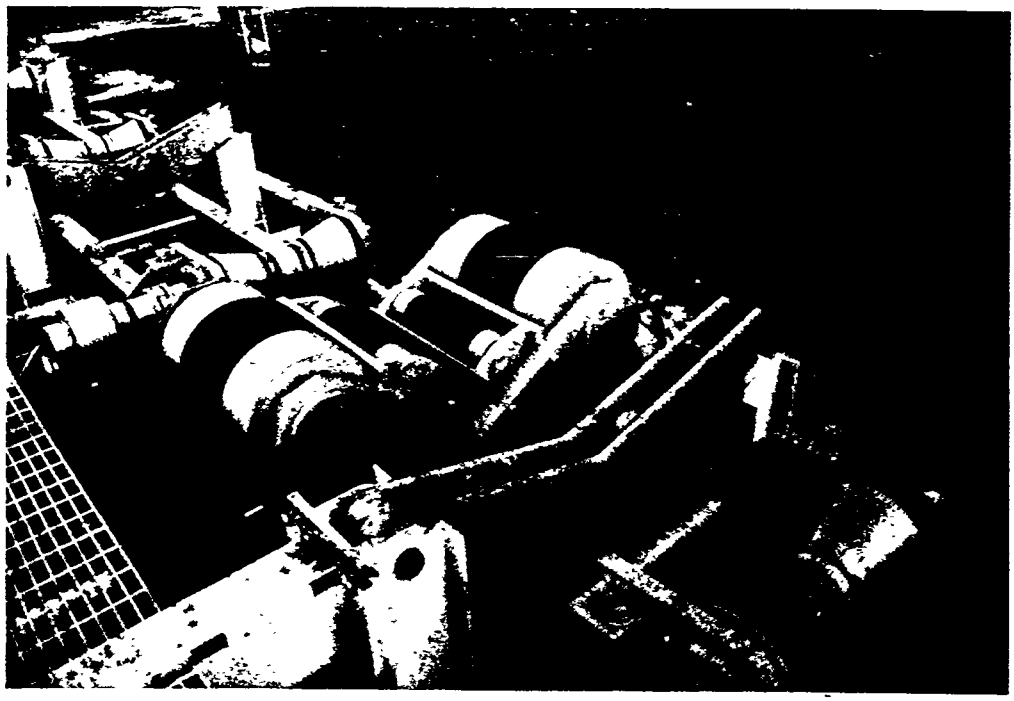


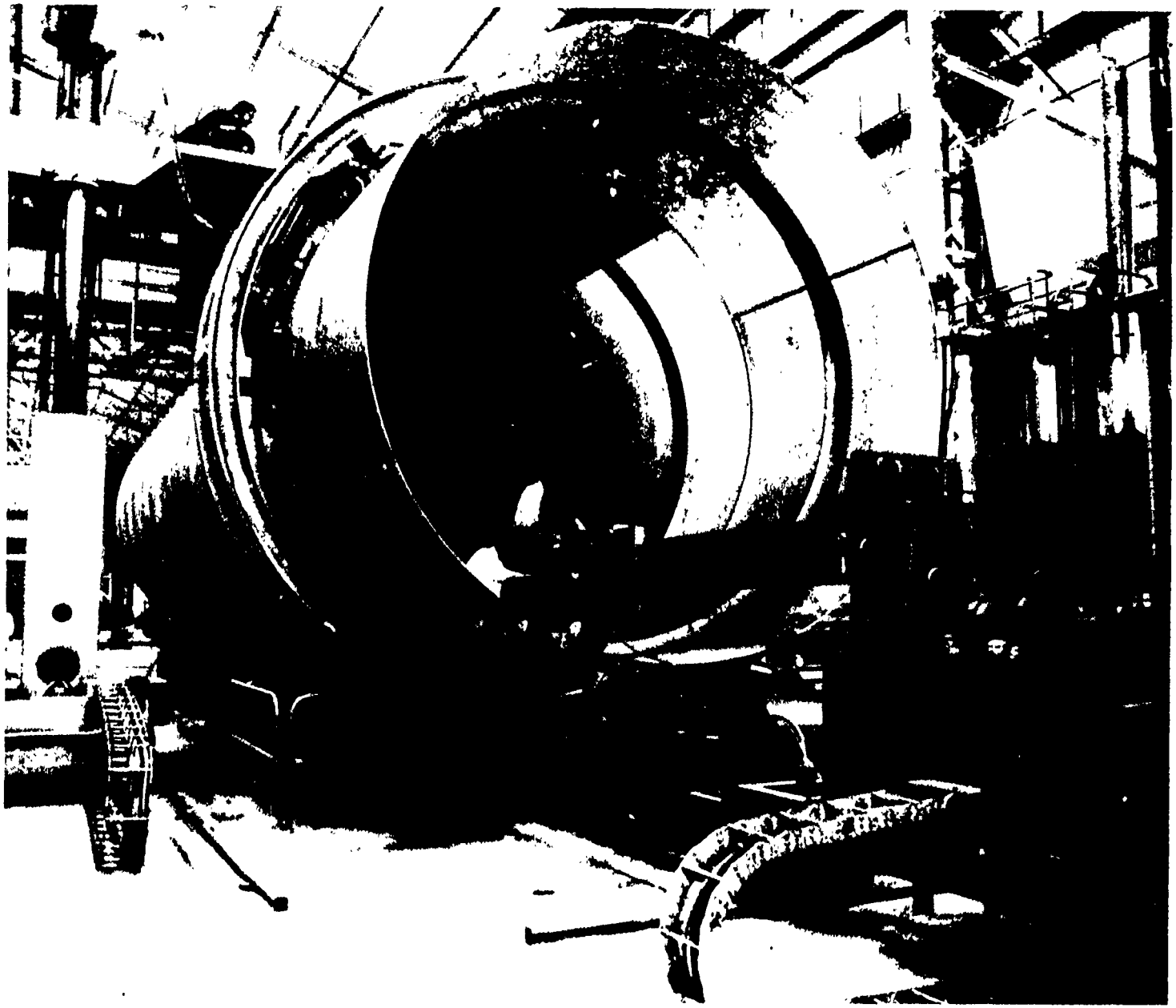
LATEST PIPE RACK IN DEUMA WORKS PRIOR TO ERECTION





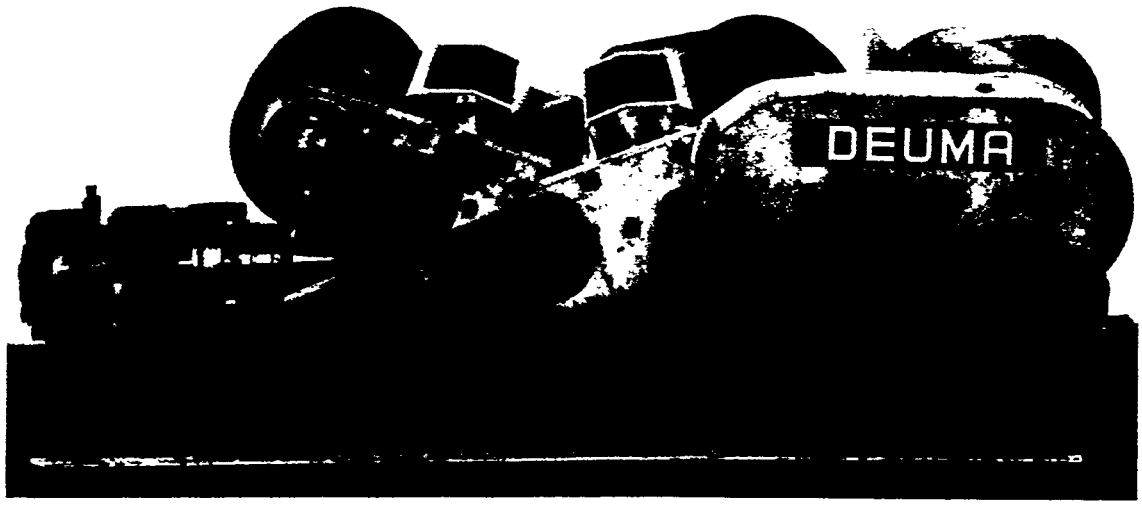
SPRING-LOADED TRANSPORT ROLLERS - DRIVEN AND UNDRIVEN





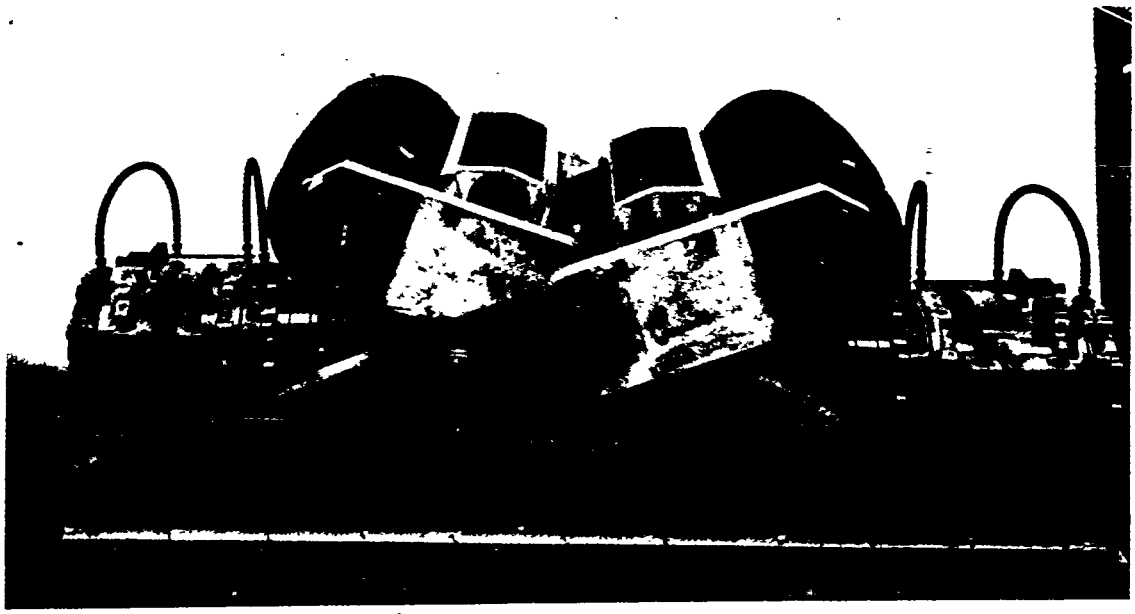
INTERNAL CIRC-WELDING MANIPULATOR [2 & 4] & EXTERNAL CIRC-WELDING MANIPULATOR [11 & 21 PRINT NO. MPS : 2]

FOR ITEMS : 5, 6, 10 and 16 ON PRINT No. MPS:2



TURNING ROLLS, DRIVEN & UNDRIVEN HYDRO-MECHANICAL CONSTRUCTION, SUITABLY BUILT TO ELEVATE AND LOWER CANS/TUBULARS FROM AND ONTO TRANSPORT ROLLERS FOR CIRC-WELDING/LONG SEAM POSITIONING OR TRANSPORT RESPECTIVELY.

INFINITELY VARIABLE DRIVE FOR CIRC-WELDING AND FAST CLOCKWISE AND ANTI-CLOCKWISE SPEED FOR LONG SEAM POSITIONING - 12 O'CLOCK FOR EXTERNAL - 6 O'CLOCK FOR INTERNAL WELDING IS INCORPORATED.

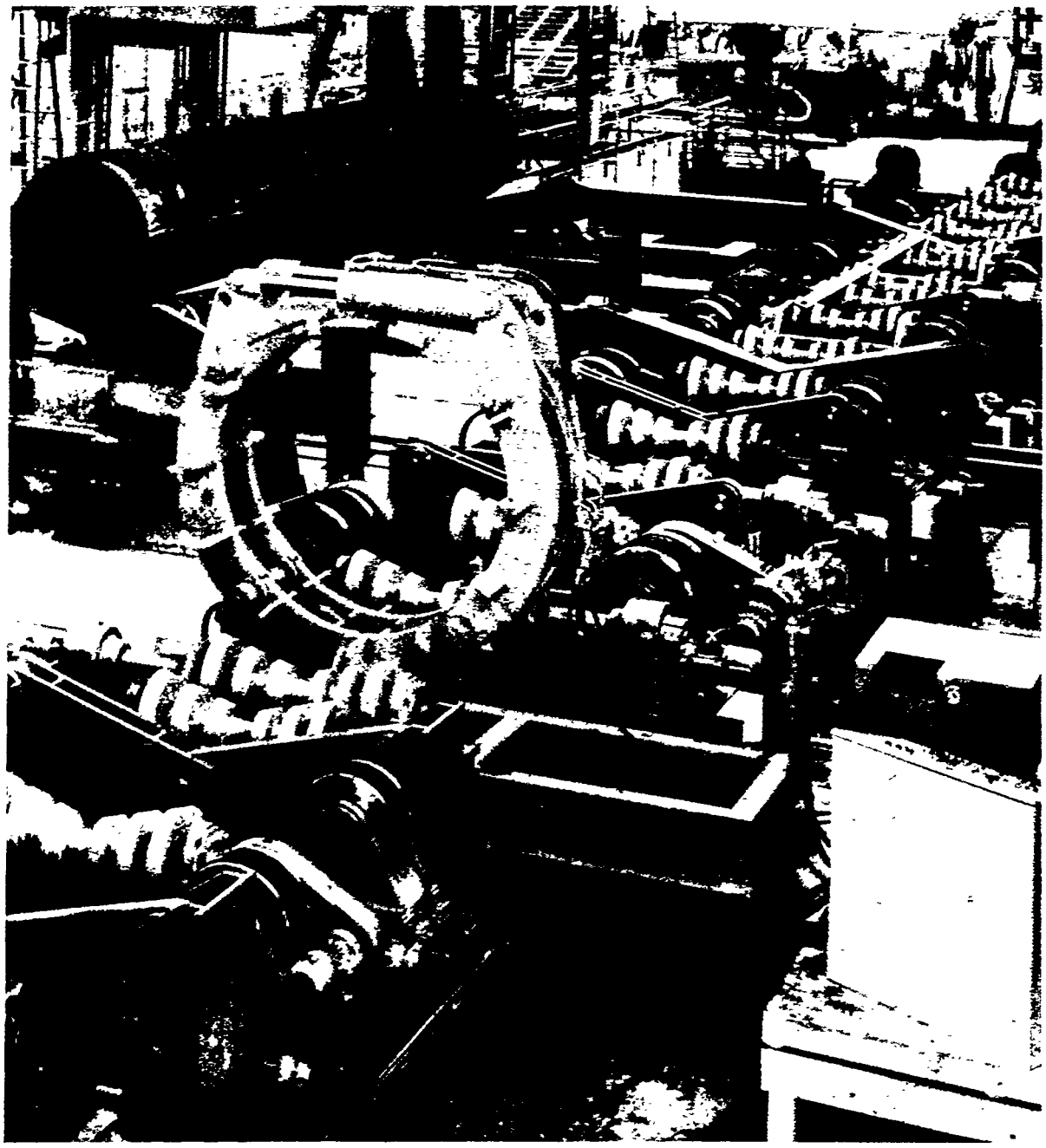


FOR ITEMS : 4 and 17 ON PRINT No. MPS:2

ALIGNING, ASSEMBLING **AND ROUNDING/CLAMPING STATION.** HIGH POWERED HYDRAULIC JACK WITH HEIGHT ADJUSTMENT **AND REMOTE CONTROL. BUILT TO POSITION ROUNDING RINGS FOR ALIGNING, ROUNDING AND ASSEMBLING TUBULARS, AS DESCRIBED BELOW.**

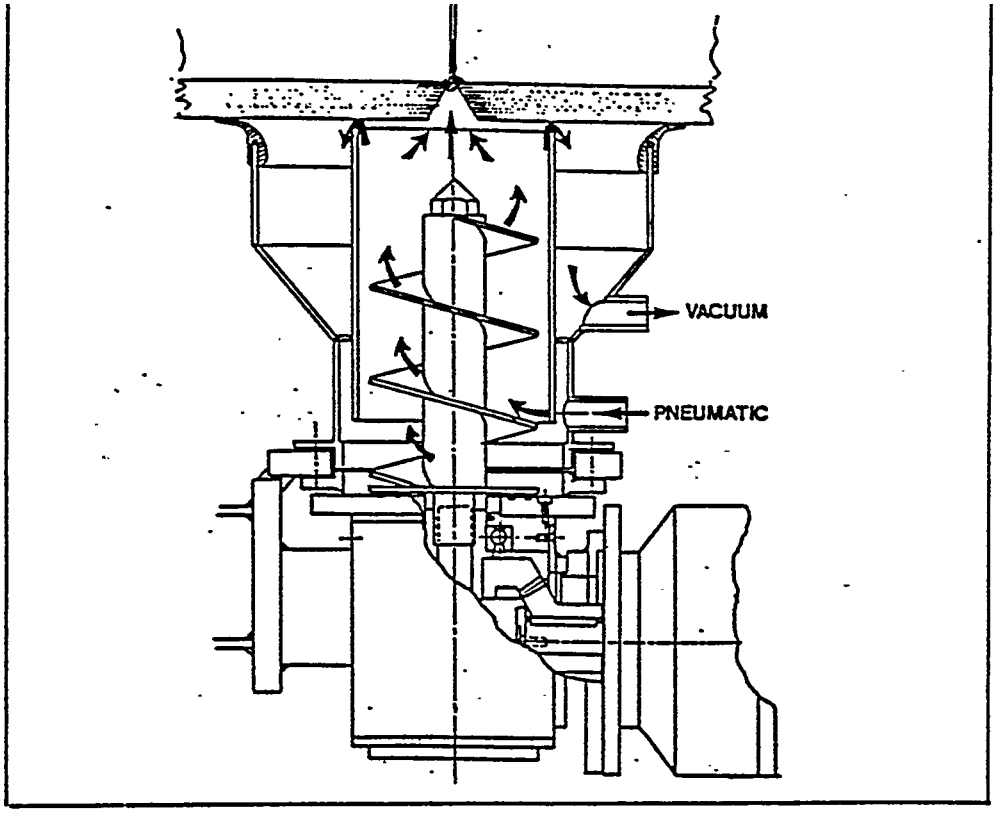
TWIN ALIGNING, ASSEMBLING AND ROUNDING/CLAMPING RINGS, HYDRAULICALLY ACTUATED TO RADIALLY **OPEN AND CLOSE [ROUNDING/CLAMPING OPERATION] ONE RING IS FIXED IN ITS HORIZONTAL AXIS, WHILE THE SECOND RING IS HYDRAULICALLY POWERED WITHIN THE SAME AXIS TO APPROACH AND WITHDRAW FROM FRIST RING [ASSEMBLING OPERATION]**

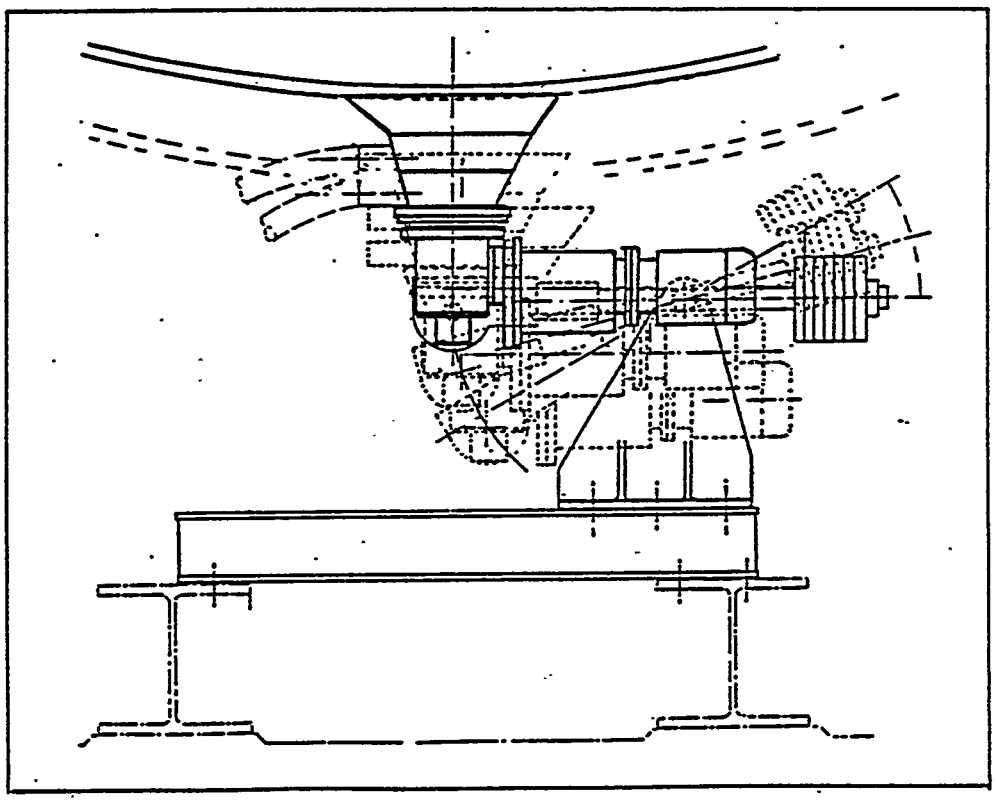
RINGS ARE CLOSED FOR TACK [MIG] WELDING OPERATION, OPENED AND LOWERED TO GIVE CLEARANCE FOR POWERED LONGITUDINAL TRANSPORTATION.



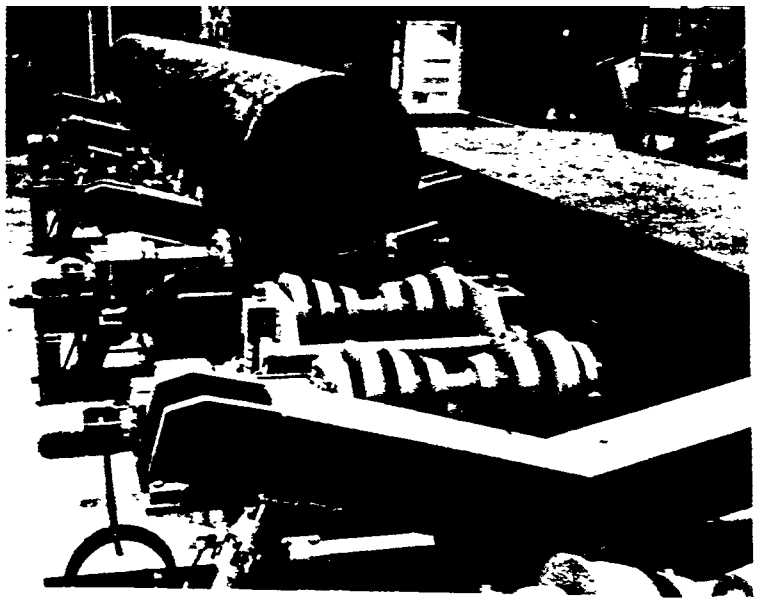
ALIGNING, ASSEMBLING & ROUNDING/CLAMPING STATION WITHIN THE PIPE MILL

5 and 18 on PRINT No: MPS : 2

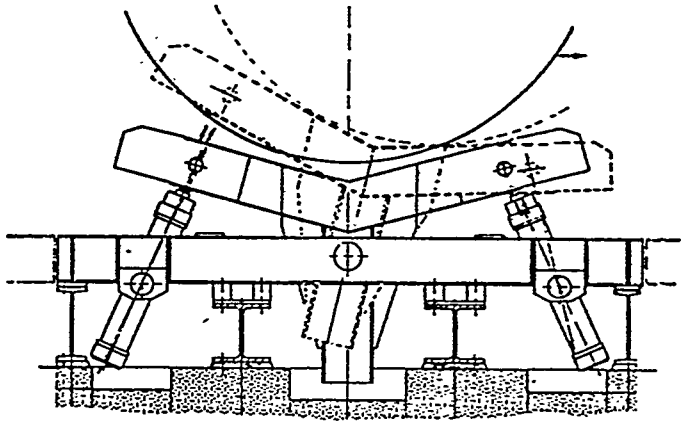


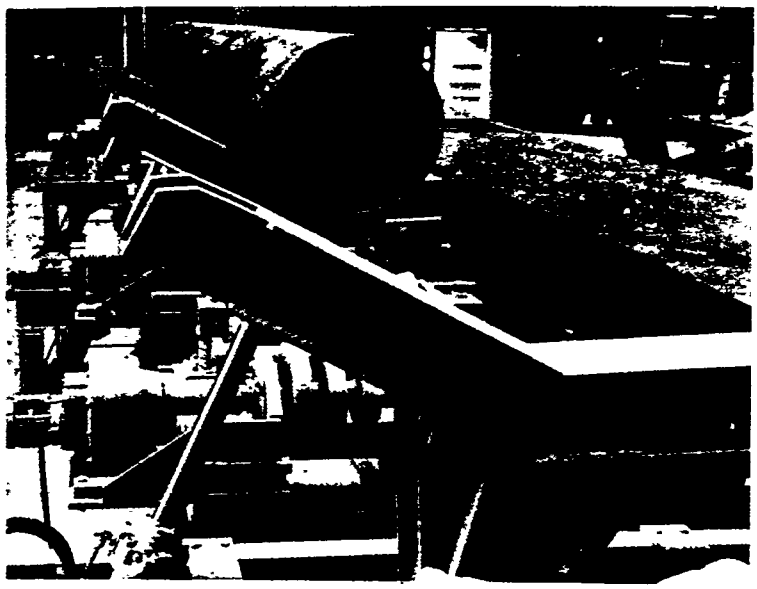


CONTINUOUS FLUX BACKING SYSTEM WITH PNEUMATIC FLUX FEED, HIGH VACUUM FLUX RECOVERY AND RE-CONDITIONING UNIT, SUITABLE FOR EXTERNAL BACKING OF INTERNAL



HYDRAULIC TRANSFER LOADERS/UNLOADERS





ADDENDUM TWO - IN ADDITION TO THE REQUIREMENT OF THIS FEASIBILITY STUDY, CONCERNING THE ASSEMBLING AND WELDING OF SHELLS AS MENTIONED ABOVE, WE ARE ALSO ENCLOSING OUR U. S. PATENT NO. 4,371,108 DESCRIBING A COMPLETE PRODUCTION SYSTEM FROM ROLLING OF PLATE TO FITTED TUBULARS.

C2.1.10

4371108

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Whereas, THERE HAS BEEN PRESENTED TO THE

Commissioner of Patents and Trademarks

A PETITION PRAYING FOR THE GRANT OF LETTERS PATENT FOR AN ALLEGED NEW AND USEFUL INVENTION THE TITLE AND DESCRIPTION OF WHICH ARE CONTAINED IN THE SPECIFICATION OF WHICH A COPY IS HEREUNTO ANNEXED AND MADE A PART HEREOF, AND THE VARIOUS REQUIREMENTS OF LAW IN SUCH CASES MADE AND PROVIDED HAVE BEEN COMPLIED WITH, AND THE TITLE THERETO IS, FROM THE RECORDS OF THE PATENT AND TRADEMARK OFFICE IN THE CLAIMANT(S) INDICATED IN THE SAID COPY, AND WHEREAS, UPON DUE EXAMINATION MADE, THE SAID CLAIMANT(S) IS (ARE) ADJUDGED TO BE ENTITLED TO A PATENT UNDER THE LAW.

NOW, THEREFORE, THESE Letters Patent ARE TO GRANT UNTO THE SAID CLAIMANT(S) AND THE SUCCESSORS, HEIRS OR ASSIGNS OF THE SAID CLAIMANT(S) FOR THE TERM OF SEVENTEEN YEARS FROM THE DATE OF THIS GRANT, SUBJECT TO THE PAYMENT OF ISSUE FEES AS PROVIDED BY LAW, THE RIGHT TO EXCLUDE OTHERS FROM MAKING, USING OR SELLING THE SAID INVENTION THROUGHOUT THE UNITED STATES.

In testimony whereof *I have hereunto set my hand and caused the seal of the* **Patent and Trademark Office** *to be affixed at the City of Washington this first day of February in the year of our Lord one thousand nine hundred and eighty-three, and of the Independence of the United States of America the two hundred and seventh.*

Attest:

Attesting Officer.

Commissioner of Patents and Trademarks.

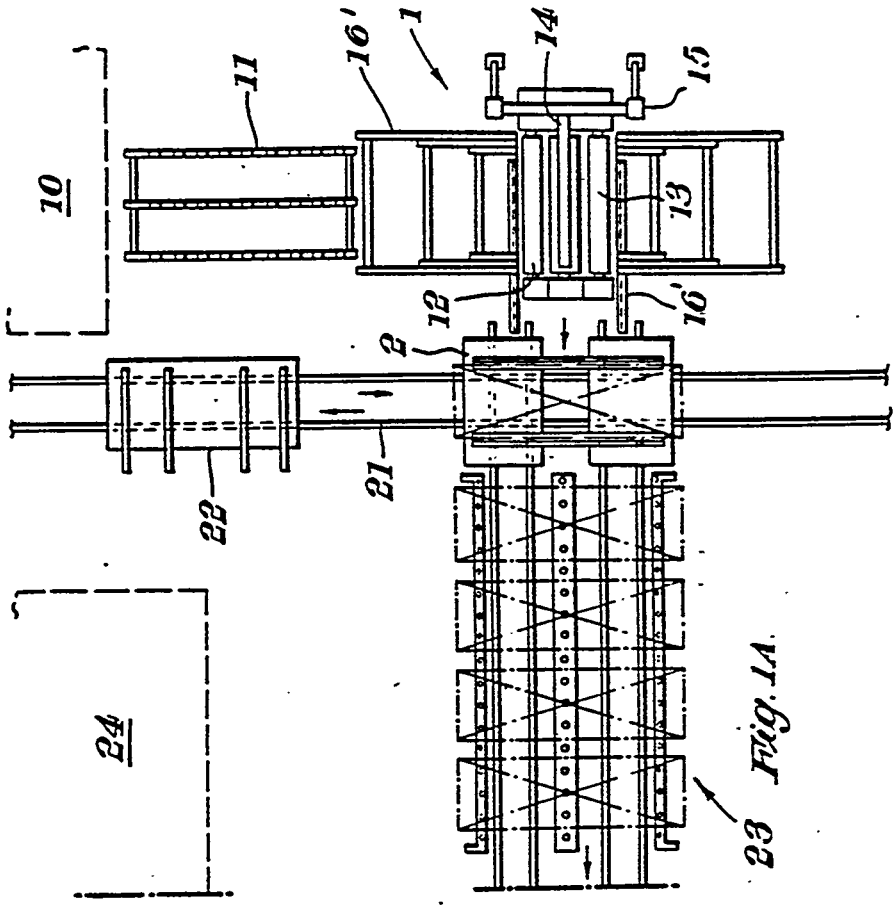


Fig. 1A

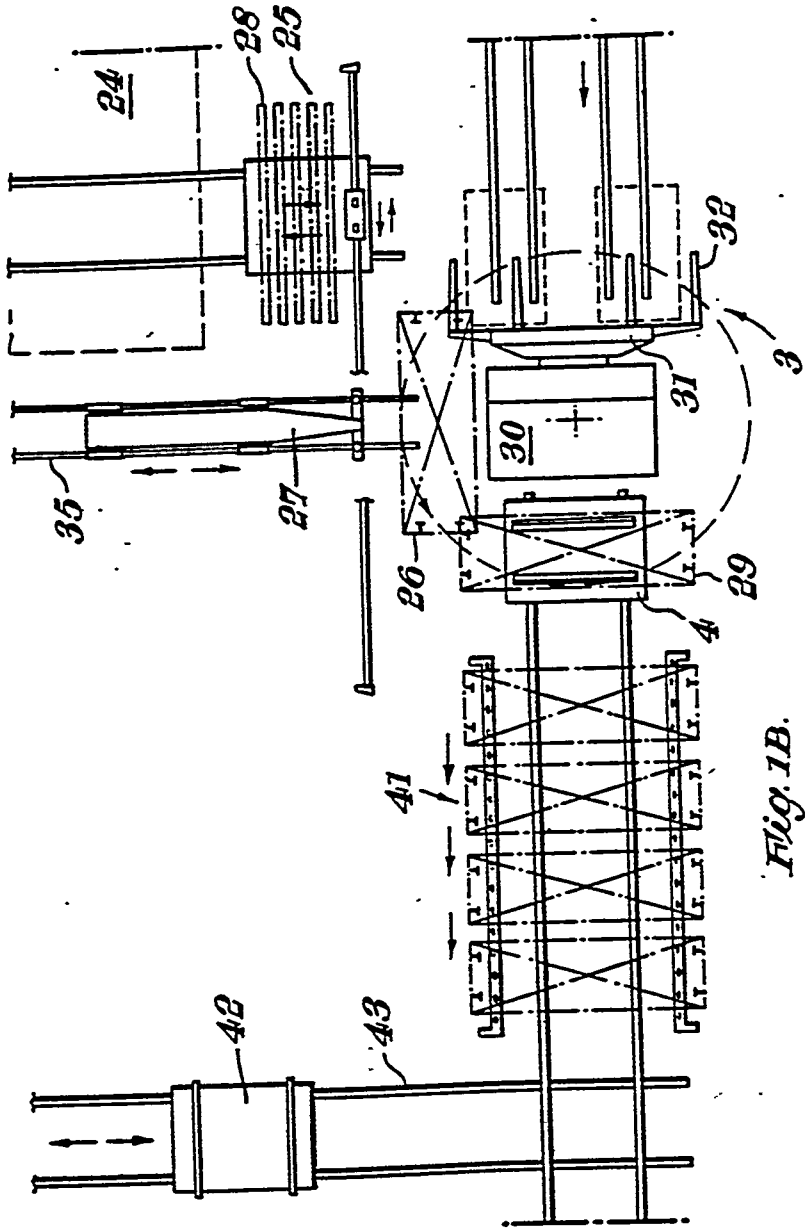


Fig. 1B.

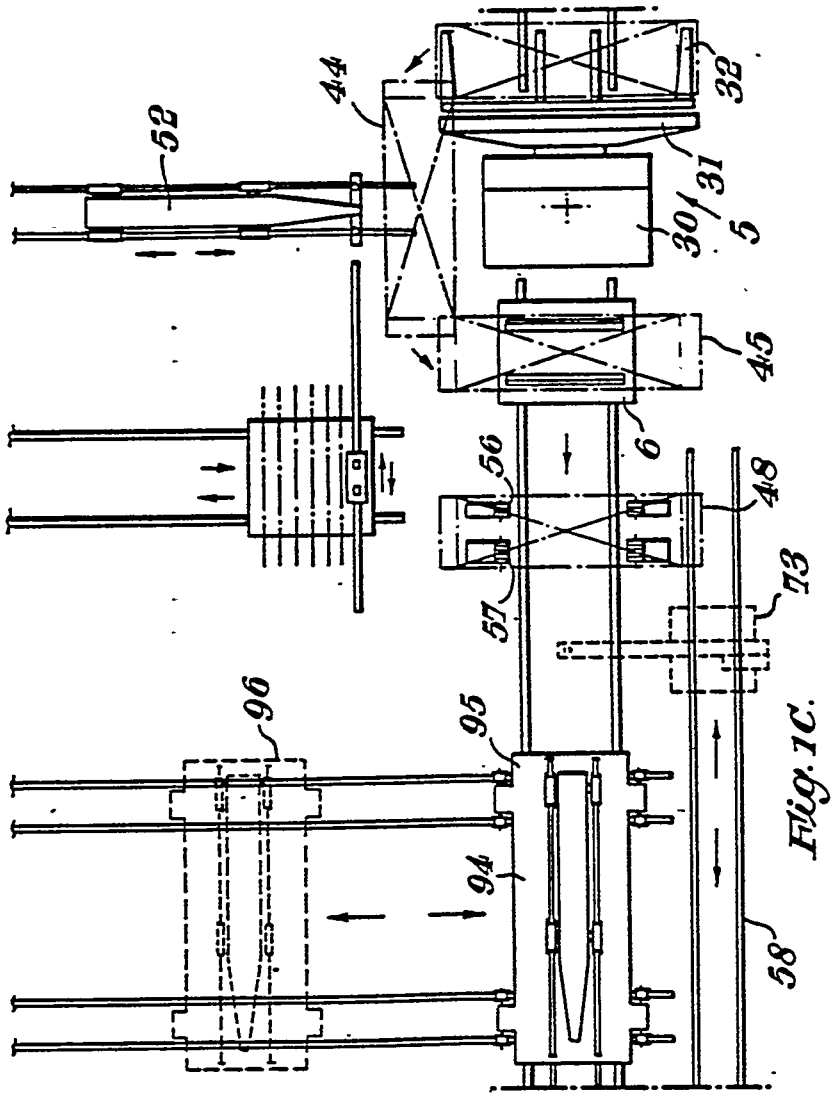


Fig. 1C.

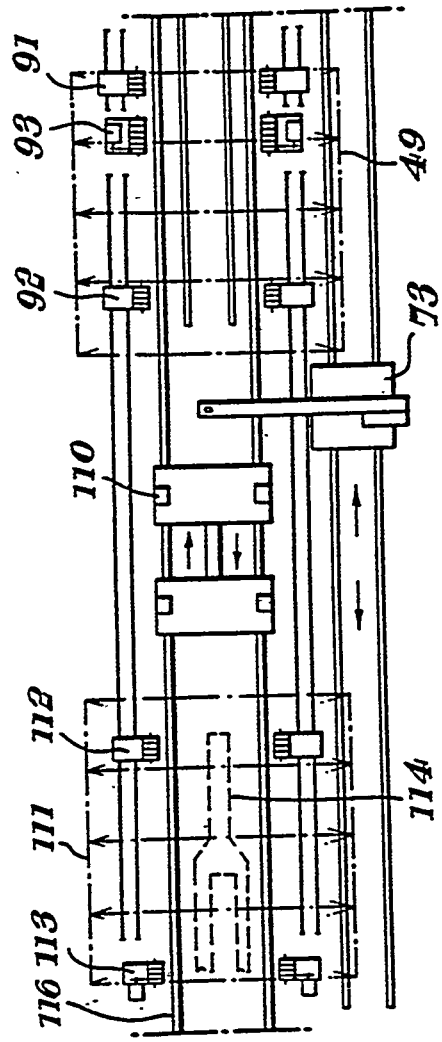


Fig. 1D.

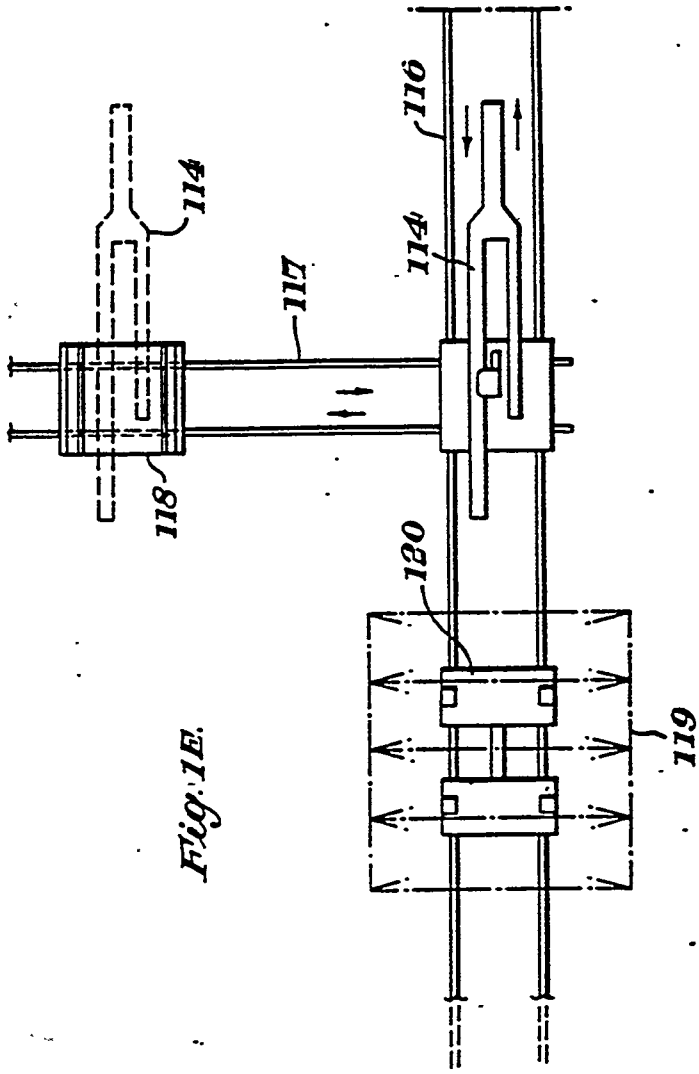
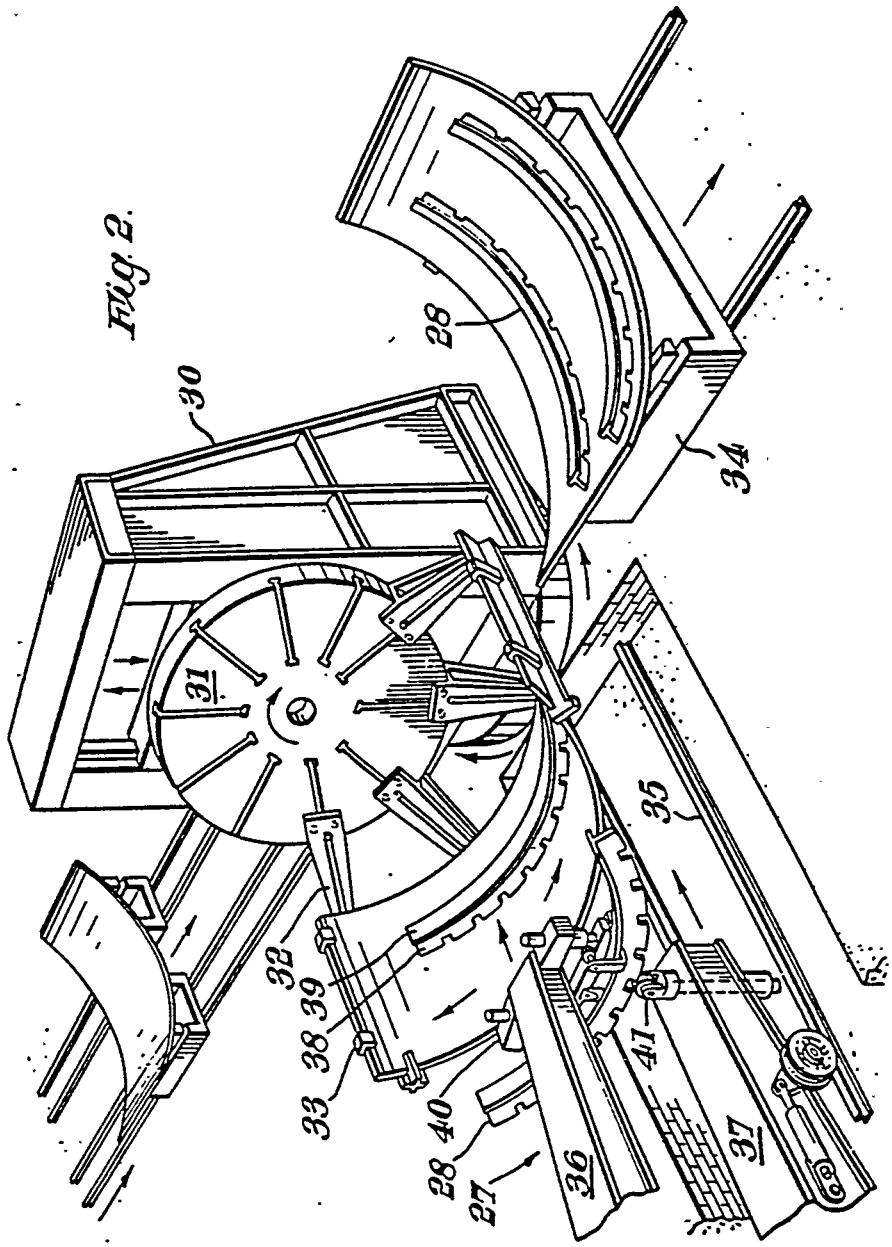


Fig. 1E.

Fig. 2.



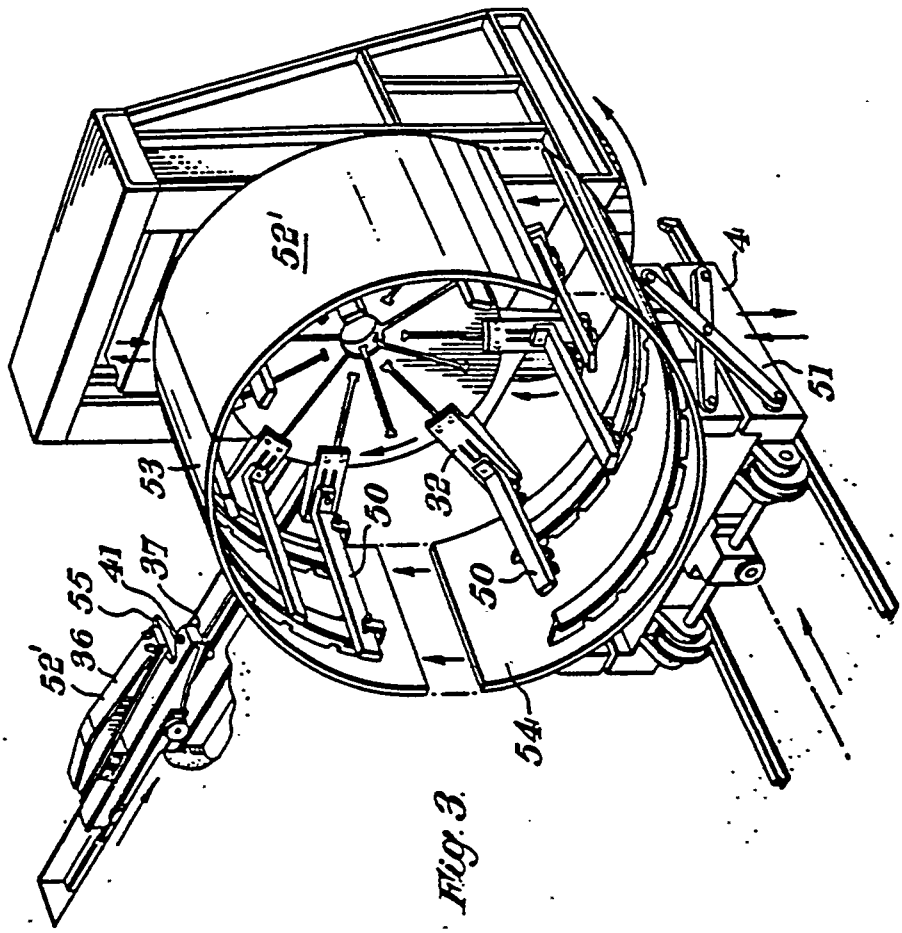


Fig. 3.

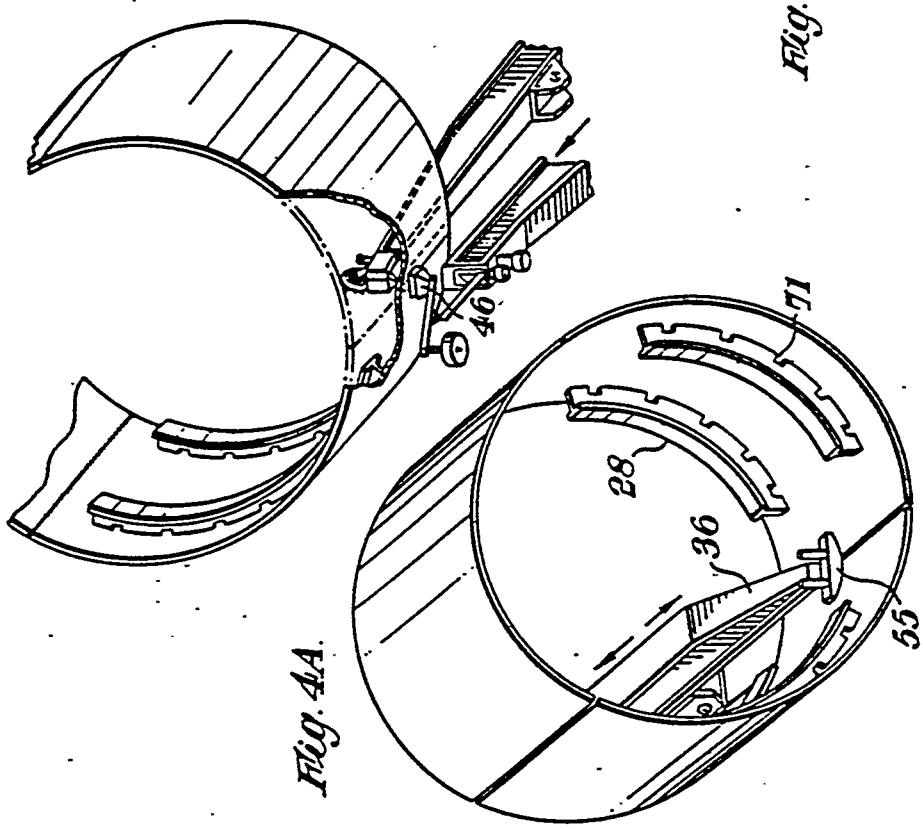
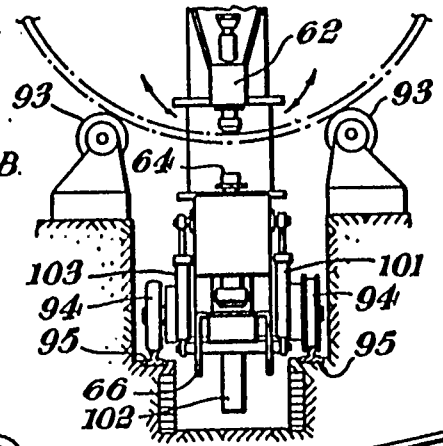


Fig. 4A.

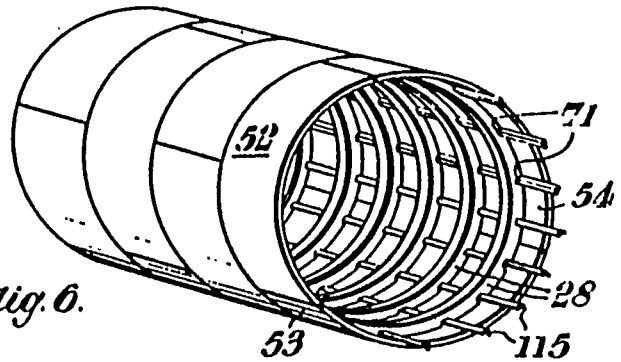
Fig. 4B.

Fig. 4C.

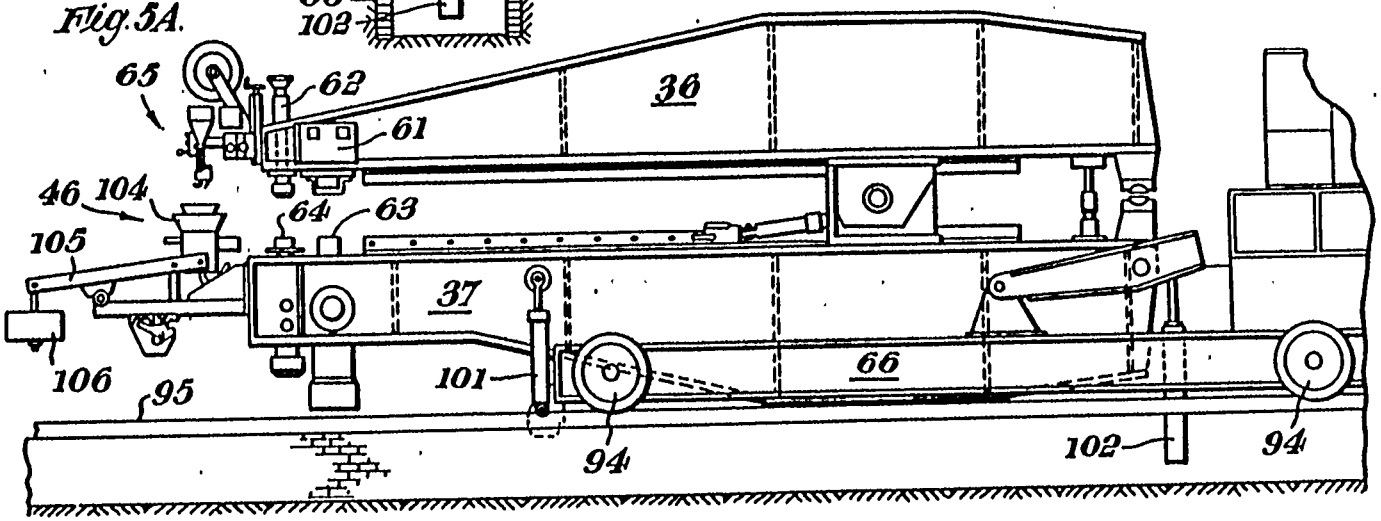
Flig.5B.



Flig.6.



Flig.5A.



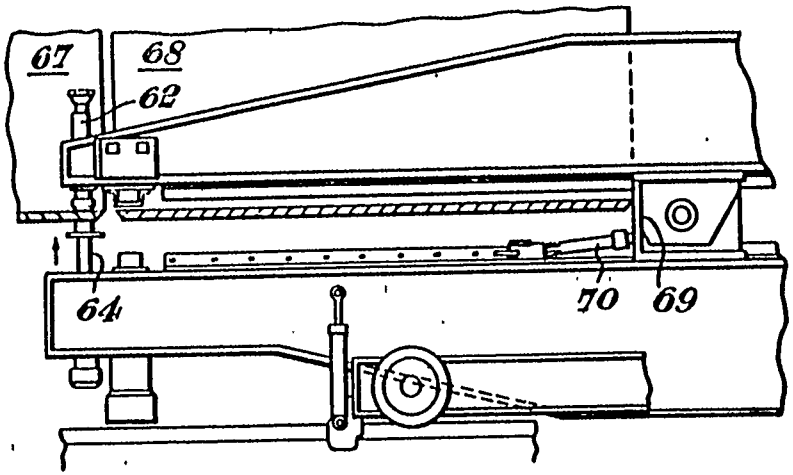


Fig.5C.

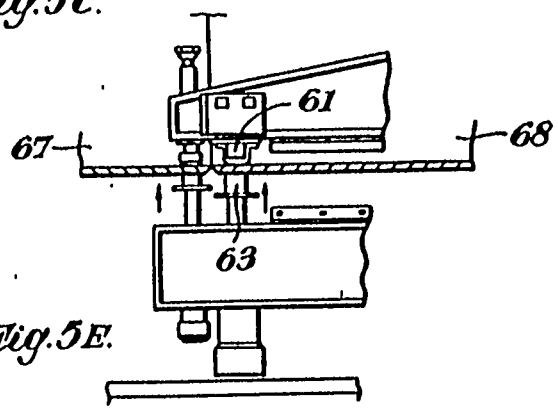


Fig.5E.

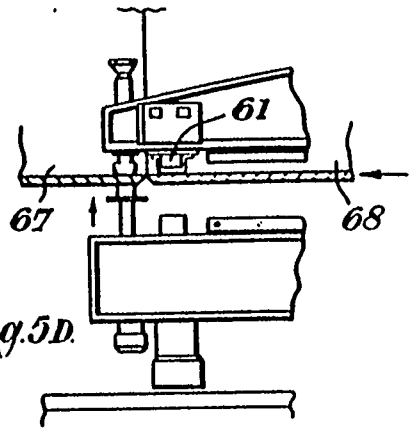


Fig.5D.

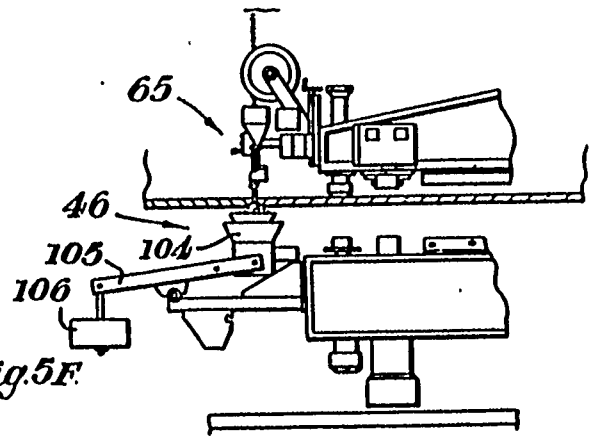
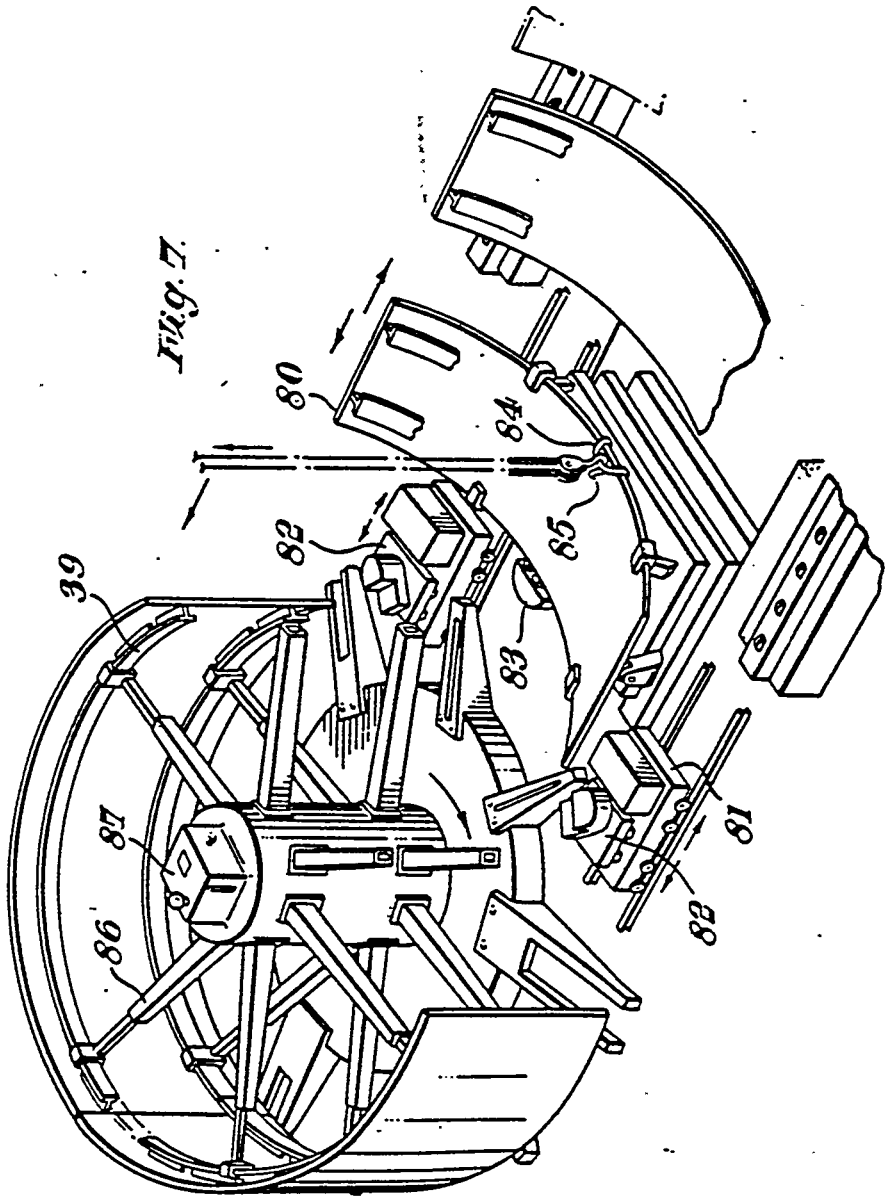


Fig.5F.

Fig. 7.



[54] METHODS OF MANUFACTURING LARGE TUBULAR COLUMNS

[76] Inventors: Stephen Roggendorff; Cuthbert J. Walker, both of 1 Cricketers Parade, Worthing, West Sussex, BN14 9DB, England

[21] Appl. No.: 188,751

[22] Filed: Sep. 19, 1980

[30] Foreign Application Priority Data

Aug. 9, 1980 [GB] United Kingdom 8026041

[51] Int. Cl.³ B23K 31/02

[52] U.S. Cl. ..... 228/173 C; 29/430; 29/469

[58] Field of Search ..... 228/47, 173 C, 184; 29/429, 430, 469

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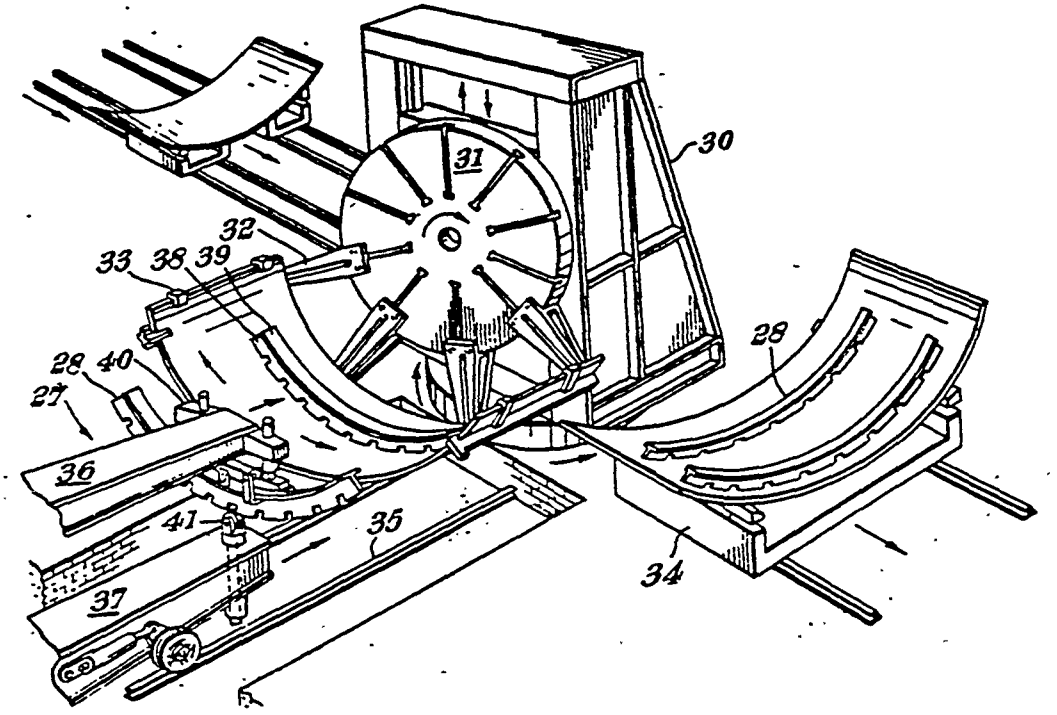
Primary Examiner—Gil Weidenfeld
Assistant Examiner—Fred A. Silverberg
Attorney, Agent, or Firm—Eyre, Mann, Lucas & Just

[57] ABSTRACT

The invention relates to a method of manufacturing large tubular columns, for example, for use as the legs of off-shore well-drilling apparatus. Each column is manufactured by initially fitting stiffening ring segments to a plurality of shell segments and then welding the shell segments together to form a column section. After additional ring segments have been fitted across the joints between the shell segments, a series of tubular sections are welded together to form the column.

11 Claims, 18 Drawing Figures



METHODS OF MANUFACTURING LARGE TUBULAR COLUMNS

This invention relates to methods of manufacturing tubular members and is particularly concerned with the manufacture of large tubular Columns, for example, for use as constructional elements of marine structures such as off-shore well-drilling apparatus or other submersible or semi-submersible structures. The invention is particularly concerned with the provision of tubular members which may be used as the legs of large marine structures.

In view of the considerab1e size and weight of many of the tubular members of the type with which the invention is concerned, it is normal practice to construct them from a *number* of parts which are assembled and welded together. Further, in view of the considerable forces which such columns have to withstand when they are in use, they must be produced very accurately and without any defects. *In the* past it has been normal procedure to use traditional constructional methods of the kind used in the ship-building industry, but it has been found that such methods suffer from disadvantagcs what adapted to the construction of large tubular columns.

Accordingly, it is an object of the present invention to provide a method of manufacturing tubular members which does not suffer from these disadvantagcs.

The invention consists in a method of manufacturing tubular members in which plate material is formed into a plurality of shell segments, in which a plurality of stiffening ring segments am secured to each shell segment, in which a plurality of stiffened shell segments arc assembled into a tubular section, and in which a plurality of said tubular sections are assembled co-axially end-to-end to form a longitudinally extending tubular member.

The invention is primarily concerned with the manufacture of members in which both the plate material and the stiffening ring segments consist of steel and welding is preferably used 10 secure the ring segments to the shell segments, to secure the shell segments to one another to form the tubular sections and also to join the tubular sections end-to-end.

Essentially the tubular members arc of circular cross-section and each shell segment may, for example be in the form of a 120 am so that three such segments constitute the complete circle preferably the ring segments are secured to the conave surface of the shell segments and have a somewhat smaller angular extent than the shell segments so that a space is left at each end of each shell segment which is free from ring segments. This space enables the abutting edges of two shell segments to be welded internally as well as externally. once the internal weld has been Completed, further ring segments are inserted between the ends of the existing segments to complete the circle of stiffening rings.

Preferably the plate material is rolled to form it into the required shell segments and each segment is transported to a positioner having clamping means mounted on a circular plate which is rotatable about a horizontal axis in a tower body which is itself rotatable about a vertical axis. After the shell segment has been secured by the clamping means, the tower body is rotated through 90° so that the stiffening ring segments can be placed in position and welded by means of an assembling and welding machine of the type which includes

upper and lower jaws. These jaws support clamping means and also welding means.

After the stiffening ring segments have been welded in position, the tower is rotated through a further 90° so that the stiffened shell segment can be transported by means of a transfer trolley to a second positioner generally similar to that already described. This positioner receives a first shell segment and supports it by means of clamping mans which engage the flanges of the stiffening ring segments. After the first shell segment has been clamped in position, the plate of the positioner is rotates! through 120° about its horizontal axis and a second shell segment is picked up by the next set of clamping means. Similarly, the third shell segment is picked up after further rotation of the plate through 120°. Thereafter, the positioner is rotated through 90° about its vertical axis to present three stiffened shell segments to a further assembling and welding machine which accurately clamps the edge portions of* shell segments in succession so that the abutting edges can be accurately lined up and tack-welded. After the tack-welding. the same assembling and welding machine is used to perform an internal weld on each scam.

The second positioner is that rotated through a further 90° to return the tubular section to the production line for the seams to be externally welded. The completed tubular sections arc then moved to a further station in which the abutting circular edges of two adjacent tubular sections are welded together by means of a further assembling and welding machine similar to those already described It is to be understood that the assembling and welding machine is provided not only with means for aligning the abutting edges of the two sections but also with means for drawing the two sections together so that the abutting edges arc in contact.

In the next stage, the circumferential joints between adjacent tubular sections are externally welded.

In a final stage, longitudinal stiffening elements are inserted in recesses provided in the stiffening rings.

The specific nature of the invention as well as other objects, advantages and features thereof. will become readily apparent from the following detailed description of preferred embodiments taken in conjunction with the accompanying drawings

FIGS. 1A to 1E represent successive parts of a method in accordance with the invention;

FIG. 2 is a perspective view of some of the equipment used in the part of the production line illustrated in FIG. lB;

FIG.3 is a perspective view of a part of the equipment used in the part of the production line illustrate d in FIG. 1c;

FIGS. 4A to 4C illustrate three of the operations carried out in the part of the production line illustrated in FIG. lC;

FIG. 5A is a side view of an assembling and welding machine used in a number of stages of the production line

FIG. 5B is an end view of the machine illustrated in FIG. 5A;

FIGS. 5c to 5F illustrate various uses of the machine illustrated in FIGS. 5A and 5B

FIG. 6 is a perspective view of a completed tubular member produced by a method in accordance with the invention; and

FIG. 7 is a perspective view of alternative equipment for usc in place of the equipment illustrated in FIG. 3.

The *emdediments* of the invention to be described are concerned with the production of tubular columns of circular cross-section from a number of tubular sections, each of which itself is produced from three shell segments . Thus the first step in the method of manufac- *ture 10 be described* consists in rolling a plurality of **flat metal** plates into shell segments , each of which spans an arc of 120°. This step is carried out on apparatus as illustrated in FIG. 1A. This apparatus includes a preparation area 10 in which the flat metal **plates are** prepared. They are transferred from this area to a loading table 11 from which they pass to a hydraulic plate-bending machine generally indicated at 1. This plate-bending machine includes lower plate rollers 12 and 13 and an upper plate roller **14. The** support for the upper plate roller includes an overhead bridge 15. The machine also includes lateral supports 16.

When the plates have been bent to the required Shape, they are moved along a roller discharge 16' to a transfer trolley 2. This transfer trolley is movable on rollers 21 so that shell segments can be transferred to second and third assembly lines if desired. A transfer bridge for the shell *segments is* indicated at 22.

Shell segments required for the assembly line illustrated are moved from the transfer trolley to a buffer station 23 **which is** provided with castors for linear movement. The reference numeral 24 indicates a preparation area for steel stiffening ring segments 28.

The leading segment in the buffer station 23 is presented to a positioner 3 which is illustrated in FIG. lB. In addition, steal stiffening ring segments 28, each of which spans an arc of about 90°, are stored on a loader 25. The positioner 3 is illustrated in more detail in FIG. 2, and it will be seen that it includes a main body 30 which is rotatable about a vertical axis. The rotatable main body carries a plate 31 which is rotatable about a horizontal axis The plate 31 carries four radially-adjustable arms 32 which themselves carry clamping means 33. AS can be seen from FIG. 2, these clamping means are capable of clamping one of the 120° shell segments on the front and rear arcuate edges as well as on the Iongitudinal side edges.

The shell segment at the head of the queue is presented to the positioner on transfer trolley 34, and is gripped by the clamping means 33. The positioner is then rotated about its vertical axis through 90° to the position shown in FIG. 2 and indicated in FIG. lB in broken lines at 26. With the positioner in this position, the shell segment is **located** to receive a pair of stiffening ring segments from an assembling and welding machine 27. This is machine travels *on rails 35* which are perpendicular *to the* extent of the production line. The machine includes upper and lower jaws 36 and 37. Each of the stiffening ring segments 28 includes a web 38 and a flange 39 and the upper jaw 36 is provided with clamping means 40 capable of gripping the flange 39 of a ring segment. The machine is moved on the rails 35 until the ring segment held by the clamping means 40 is correctly positioned longitudinally with respect to the shell segment held by the clamping means 33. The jaw 36 **is then** lowered until the ring segment is in contact with the shell segment . *A roller jack 41 is then raised in* **contact with the lower** side of the shell segment. When the first ring segment is accurately positioned relative to the shell segment, it ix tack-welded inposition. Thereafter, an automatic continuous welder (not shown) carried on the end of the jaw 36 is swung into the position in front of the clamping means 40 and the clamping means are released so that the assembling and welding machine 27 can be retracted to the required extent to bring the welder into position to weld the flange 38 of the ring segment to the shell segment . For this operation. the plate 31 is initially rotated about its horizontal axis until the welder is located adjacent to one end of the ring **segment.** and is there after rotated at welding speed so that a continuous weld can be produced.

After the first ring segment has been welded into position, a Second ring segment **is placed** in position by the assembling and welding machine. and the process described above is repeated. Thereafter the assembling and welding machine is retracted. and the positioner 30 is rotated through a further 90° to the position indicated in FIG. lB by broken lines 29. The shell segment. together with its two stiffening ring segments is then deposited on a transfer trolley 4 and moved *into a* buffer station 41. If desired, assembled shell and ring segments can be *moved to* and from a second assembly line or a quality control area by means of a transfer bridge 42 and r a i l s 4 3 .

The **leading** shell segment in the queue for the assembly line illustrated is moved up **to** a second positioner 5 shown in FIG. **lC and generally** similar to the positioner 3. The positioner 5 is illustrated more particularly in FIG. 3. and it will be seen that it is provided with nine radii arms 32 which have a different form of clamping means from that shown *in FIG.* 2. In this case, the clamping means 50 are designed to grip the flanges 39 of the stiffening ring segments. The transfer trolley 4 is provided with jack means , generally indicated at **51, for raising** and lowering the shell segment which it is carrying. Thus, after the trolley has been moved into position below three of the clamping means 50, it can be raised so that the segment can be held by these clamping means. After one segment 52 has been picked up by the positioner, the plate 31 is rotated through 120°, and a second segment 53 is moved into position by the respective trolley. It is then picked up by the next three radii arms, and the plate 31 is rotated through a further 120°. The third segment 54 is then moved into position as shown in FIG. 3. It can be seen that the first segment 52 has been rotated through 240°, and the second segment 53 has been rotated through 120°. The third segment 54 is then raised on its trolley so that it can be gripped by the three clamping means so which are now in the lowermost position. When the three segments have ban picked up *by* the respective clamping means the positioner 5 is rotated through a further 90° about its vertical axis into the position indicated in broken lines in FIG. **1C at 44.** In this position, **a** second assembling and welding machine 52' is located ready for carrying out the next steps in the production process.

The plate 31 of the positioner 5 is now rotated so that the abutting edges of **two** of the shell segments are located vertically below the axis of rotation of the plate. It is to be **understood that, while the** positioner is in the position shown in FIG. 3, the clamping means 50 are used to ensure that the arcuate edges of the shell segments are located in parallel planes, and also to ensure that the abutting edges of the segments, are as close together as possible **However, final alignment of the** abutting edges is carried out by means of the assembling and welding machine 52'. For this purpose the jack 41 on the lower jaw 37 of the assembling and welding machine is located below the lowermost pair of abutting edges, and the arcuate member 55 on the upper jaw 36 is located above these two edges The clamping action

of the two jaws is then used to produce perfect alignment of the two abutting edges as shown in FIG. 4A, and the seam is tack-welded. When the joint is secure, the clamp is released and the continuous welding apparatus shown diagrammatically in FIG. 4B is swung into position. The internal weld of the seam is then completed.

It is, of course, to be understood that, during this welding process, the tack welds will be remelted. It can also be seen from FIG. 4B that a motorized flux backing system 46 is mounted on the lower jaw 37 and travels along the back of the seam as it is being welded.

After the first seam has been welded, the plate 31 is rotated through 120°, and the second welding operation is carried out. Thereafter the plate is again rotated through 120°, and the third seam is completed.

When the three welds have been completed, the assembling and welding machine 52' is used to place further stiffening ring make-up segments 47 in position between the ends of the ring segments 28 which have already been welded to the shell segments. This part of the operation is illustrated in FIG. 4C. After each additional ring segment 47 has been placed in position by the assembling and welding machine 52', it is tack-welded and then, after the segments 47 have been released, the weld is completed by the assembling and welding machine in the same way as described with reference to FIG. 2. To assist in insertion of the additional stiffening ring segments 47 into position, it is preferred that the ends of all the stiffening ring segments 47 and 28 should be cut on a radius of the completed tube.

The positioner 5 is now rotated through a further 90° so that the tubular section made up from the three shell segments 52, 53 and 54 is in the position shown in broken lines in FIG. 1C at 45. The tubular section is lowered by the positioner on to a further transfer trolley 6, and is then moved into the position indicated at 48 where it is carried on idler rollers 56 and driven rollers 57. An external welding boom 73 is then moved into position on rails 58, and the tubular section is rotated until one of the seams is uppermost. The external welding boom is then used to weld the outside of this uppermost seam. The tubular section is then rotated through 120° twice to enable the two other seams to be externally welded.

The completed section is now moved into the position indicated at 49 in FIG. 1D. In this position, the completed sections are supported on idler rollers 91 and 92 and driven rollers 93. When two sections have been assembled, a third assembling and welding machine 94 (FIG. 1C) is moved on a transfer bridge 95 from the side position shown in broken lines at 96 to the position shown in full lines in FIG. 1C. In this position, the assembling and welding machine 94 is used to join together the two assembled sections by means of an internal circumferential weld. This operation is shown in more detail in FIGS. 5A to 5F.

FIGS. 5A and 5B show the assembling and welding machine 94 in more detail, and it can be seen that this machine includes the upper jaw 36 and the lower jaw 37 previously referred to. Mounted on the upper arm are two hydraulic presses 61 and 62. These cooperate respectively with sub-presses 63 and 64 on the lower jaw 37. This illustration also shows the seam welder 65 and the motorised flux backing system 46. The lower jaw 37 is mounted on a chassis 66 by means of three hydraulic jacks 101, 102 and 103, which enable the height and attitude of the jaws to be adjusted as required. The chassis 66 is supported on wheels 94 which run on rails 95.

FIG. 5C shows the trailing edge of a first tubular section 67 clamped between the press 62 and the sub-press 64. This Figure also shows a second tubular section 68 which is to be joined to the section 67. It will be seen that the rear end of the section 68 abuts up against a pressure plate 69 controlled by a hydraulic cylinder 70. The pressure plate 69 is advanced under the control of the hydraulic cylinder 70 until the edges of the two tubular sections 67 and 68 are brought into contact as shown in FIG. 5D. The press 61 and sub-press 63 are then closed to clamp the section 68 as shown in FIG. 5E. While the two sections are clamped in this manner, they are tack-welded on either side of the clamping presses. The presses and sub-presses are then released and the two tubular sections are rotated about their axes by means of the driven rollers 93. The clamping presses are then closed again and further tack-welds are made. This process is repeated until the full circumference is tack-welded. Thereafter the two presses 61 and 62 and the two sub-presses 63 and 64 are released and the assembling and welding machine is retracted so that the welder 65 is located adjacent to the abutting edges as shown in FIG. 5F. The two tubular sections 67 and 68 are then rotated at welding speed and the internal circumferential weld is completed. During this process the underside of the weld is protected by the motorised flux backing system 46. It will be seen that the flux container 104 is mounted on a lever arm 105 and is supported against the underside of the weld by a weight 106. A motor-driven screw feeds a continuous supply of flux to the back of the weld and an automatic suction recovery system returns flux to the container to minimise wastage.

The external welding boom 73 is then moved on the rails 58 until it is in position to complete an external weld of the seam between the two tubular sections.

The two sections are then moved forwardly on the turning rolls assisted by the transport carriage 110 and the assembling and welding machine 94 is moved back into the side position as shown at 96 (FIG. 1C) to enable a third tubular section to be moved up on the transfer trolley to the position indicated at 49. The second circumferential seam is now welded internally and externally in the manner already described, and the three sections are moved forwardly to enable a fourth section to be accommodated in position 49.

It is to be understood that the number of sections joined together at this stage may be varied in accordance with requirements. However, in one particular embodiment, four sections each having an axial length of ten feet and a diameter of thirty-five feet are welded together to form a forty foot tubular member.

When the required number of sections have been joined together, the complete assembly is loaded off the rollers 91, 92 and 93 and onto a transport carriage 110, by means of which is is moved to the position indicated at 111. In this position the assembly is supported on turning rollers 112 and 113.

It will be seen that the webs 38 of the stiffening ring segments are provided with recesses 71. It is to be understood that these recesses are all longitudinally aligned along the length of the tubular member and, when the required number of tubular sections have been assembled, longitudinal stiffeners 115 are inserted in these recesses and welded into position by means of a feeding and welding machine 114. This machine is

shown in full lines in FIG. 1E and in broken lines in FIG. 1D, and the completed tubular member with the longitudinal stiffeners 115 in position is shown in FIG. 6.

It will be seen that the feeding and welding machine 114 is movable from the position shown in FIG. 1E to the position shown in FIG. 1D on rails 116. It is also movable to a position at the side of the production line on rails 117 by means of a transfer bridge 118. When all the longitudinal stiffeners have been inserted and welded in position as shown in FIG. 6, the feeding and welding machine 114 is moved into the side position and the completed tubular member is moved to the position indicated at 119 on a transport carriage 120 which also runs on the rails 116.

In the case of very large diameter tubular members, it may be difficult to assemble the three segments about a horizontal axis as described with reference to FIG. 3. In this case, the shell segments with their stiffening ring segments welded in position are assembled about a vertical axis by means of apparatus as shown in FIG. 7. It will be seen that, in this case, the shell segments 8 are moved on trolleys similar to those described with reference to FIG. 3, but that, when the segments reach the assembling jig, they are tilted through 90° by means of a shop crane so that they can be assembled about a vertical axis. It will also be seen that they are tilted on to trolleys 81 which are movable longitudinally with respect to the production line and include platforms 82 which are adjustable vertically. These platforms carry rollers against which the concave surface of the segment 80 abuts when it has been tilted. It will also be seen that, during the tilting process, the forward edge of the segment 80 is held by clamping means 83 which is mounted on an arm capable of pivotting about a horizontal axis perpendicular to the longitudinal direction of the production line. Also mounted on the pivotting arm is a further clamp 84 which engages the rear arcuate edge of the shell segment. The clamping means 84 is provided with ring means to receive the hook 85 of the shop crane.

Each of the three 120° shell segments is tilted into position, and then engaged by radial arms 86 mounted on a hub 87 which is rotatable about a vertical axis. The arms 86 include adjustable clamping members capable of engaging the flanges 39 of the stiffening ring segments. The arms 86 are capable of moving independently to locate the shell segments accurately with respect to each other. When they have been accurately located, the seams are welded internally by means not shown.

What we claim is:

1. A method of manufacturing tubular members in which metal plate is rolled into a plurality of shell segments of arcuate cross-section, in which each of said rolled shell segments is transported to a first positioner having clamping means mounted on a circular plate which is rotatable about a horizontal axis in a tower body which is itself rotatable about a vertical axis, in which a plurality of metal stiffening ring segments of arcuate cross-section are welded to the concave surface of each of said rolled shell segments to form stiffened shell segments, the angular extent of each of the ring segments being less than that of each of the the shell segments so that a space is left at each end of each of the rolled shell segments which is free from ring segments, in which a plurality of stiffened shell segments are assembled and welded together to form a tubular section, and in which a plurality of said tubular sections are assembled coaxially end-to-end and welded together to form a longitudinally-extending tubular member.

2. A method as claimed in claim 1, wherein after each of said rolled shell segments has been clamped in position in said clamping means, the tower body is rotated about its vertical axis so that the stiffening ring segments can be placed in position and welded to each of the rolled shell segments by means of an assembling and welding machine which includes upper and lower jaws supporting clamping means and welding means.

3. A method as claimed in claim 2, in which, after the stiffening ring segments have been welded in position, the tower is again rotated about its vertical axis so that the stiffened shell segments can be transported to a second positioner having clamping means mounted on a circular plate which is rotatable about a horizontal axis in a tower body which is itself rotatable about a vertical axis.

4. A method as claimed in claim 3, in which each of the stiffening ring segments comprises a flange and a web, in which the web of each of said stiffening ring segments is welded to a respective shell segment, and in which the clamping means of said second positioner are adapted to engage the flanges of the stiffening ring segments.

5. A method as claimed in claim 4, in which, after each of the rolled shell segments has been clamped in position, the circular plate of the second positioner is rotated about its horizontal axis, and another rolled shell segment is picked up by a further set of clamping means, whereafter the circular plate is again rotated about its horizontal axis to enable still another rolled shell segment to be picked up.

6. A method as claimed in claim 8, in which, after the number of shell segments required to complete the tubular section have been picked up by the second positioner, the second positioner is rotated about its vertical axis to present the stiffened shelf segments to a further assembling and welding machine which accurately clamps the edge portions of the shell segments in succession so that the abutting edges can be lined up to form seams therebetween and tack-welded.

7. A method as claimed in claim 6, wherein, after the tack-welding of each of the seams the clamping means of the further assembling and welding machine are released and the said further assembling and welding machine is used to perform an internal weld on the seams.

8. A method as claimed in claim 7, wherein, when the joints between the abutting edges of the shell segments forming the tubular section have been completed, further ring segments are inserted between the ends of the previously fitted ring segments to complete each circle of stiffening ring segments.

9. A method as claimed in claim 8, in which, after the further ring segments have been welded in position, the second positioner is rotated about its vertical axis to enable the seams between the abutting edges of the shell segments to be externally welded.

10. A method as claimed in claim 9, wherein the completed tubular sections are moved to a station in which the abutting circular edges of two adjacent tubular sections are welded together by means of a further assembling and welding machine provided not only with means for aligning the abutting edges of the two sections, but also with means for drawing the two sections together so that the abutting edges are in contact.

11. A method as claimed in claim 8, wherein the angular extent of each of the shell segments is 120°, the angular extent of each of the stiffening ring segments is 90°, and the angular extent of each of the further ring segments is 30°.

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